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TRANSPLANTATION OF TOES FOR FINGERS

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THE attempts at restoring defects of the skin on fingers after the methods of Italian plastics (Nicoladoni, Coucher) have led Nicoladoni to develop the idea somewhat further. Taking into consideration the functional importance of the thumb, Nicoladoni,[3] as early as 1891, made an attempt to compensate a considerable defect of the soft parts of the thumb by means of a corresponding flap grafted from the anterior wall of the thorax. The results obtained were fairly satisfactory.

The success of the case led him to further try the possibility of replacing lost parts of fingers or even the whole of an amputated finger. He intended inserting into the cutaneous rudiment of the thumb an osteoperiosteal graft, which had been slightly cracked with the view of giving it a bend. Unfortunately, he was prevented from applying the idea on a suitable case because another surgeon had performed an amputation. Following the same plan Nesske succeeded in two cases in restoring defects of the thumb with satisfactory cosmetic and functional results; the method has also been applied during the last few years by other surgeons and has been found to give satisfactory results. The operation is performed in two stages (Ritz) or sometimes even in one (Neigeisser). The former of the two surgeons, having split in half the fourth metacarpal bone, longitudinally sutured it together with the epiphysis into a cutaneous fold of the abdomen and then transplanted it on to the stump of the thumb; the results proved to be highly satisfactory. In 1898, Nicoladoni[3] succeeded in obtaining even better results by utilizing the idea of an operation which had occurred to him a year previously, *i.e.*, by substituting part of the second toe on the corresponding side of the body for a partial defect of the thumb.

Eiselsberg[1] used the same method for replacing the distal half of the index. Likewise, Krause[2] (1906) substituted for both cosmetic and functional considerations the big toe for the thumb. Klemm performed the same operation with excellent functional results in replacing a thumb which had been cut off with an axe at the metacarpophalangeal articulation. In two years sensation was found to be completely restored. The above observations show the possibility of an autoplastic substitution for part of a finger or even a whole finger, followed by its function being completely re-

stored. This is of particular importance in the case of the thumb and the index, but other fingers as well may be of great value, dependent on the patient's occupation. However, it should be borne in mind that patients submitting to the operation have to put up with a considerable amount of inconvenience in connection with a plaster-of-Paris bandage binding their

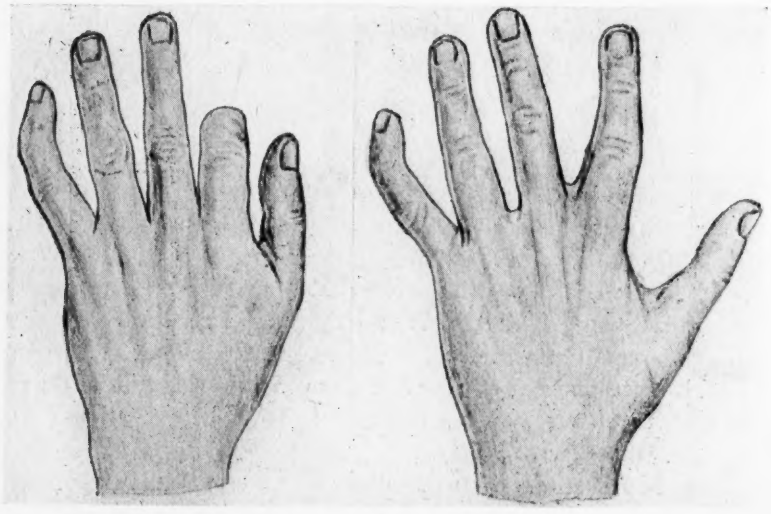

FIG. 1.—Showing site of amputation of left index finger.

FIG. 3.—Appearance of left index finger (toe) three years postoperative.

wrist and foot for a period of from two to three weeks, the body remaining during this period in a bent posture (Fig. 2). This is impossible in the case of stout people and is not endured by those suffering from hysteria. A primary grafting under conditions of a fresh trauma should be considered

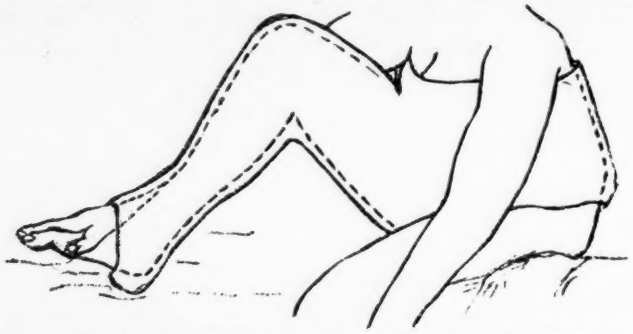

FIG. 2.—Showing position necessitated by application of plaster case, in order to maintain the apposition of wrist to foot.

decidedly unadvisable, for surgical interference within the region of recently injured tissues involves considerable danger and it appears to be hardly reasonable to sacrifice at this time a portion of an injured finger with the object of operating on sound tissues.

We perform the operation in two stages. The first stage consists in a small cutaneous flap being formed on the dorsal surface of the toe by means

of a transverse arched incision, the apex of the curve being directed posteriorly. The tendon of the extensor is sectioned if possible above the edge of the cutaneous flap. The phalanx is split transversely at the level of the base of the flap either by means of an osteotome or a Liston's forceps, or it is cut by means of a Gigli saw at a level which corresponds to the length of the defect. The distal end of the phalanx is then dislocated and the end of the thumb or finger stump is drawn up so as to come in touch with it, after a small dorsal flap of skin has also been formed on the stump and the tendon of the extensor has been exposed. The ends of the tendons are sutured together while a stable contact between the sectioned surfaces of the bones is ensured by means of suturing the surrounding soft tissues. The dressing material directly covering the wound may be fixed in place by strips of adhesive plaster and then a plaster-of-paris bandage joining the upper and

FIGS. 4 and 5.—Photographs of finger, showing excellence of cosmetic appearance and functional capacity.

lower extremities (the knee being bent) is applied. In 18 to 20 days the second stage of the operation is performed, which is analogous to the first stage, except for its being applied to the volar surface of the finger and toe and the tendons of the flexors and the incisions being sutured. In spite of a fairly long interval between the two operations, vascularization in the separated toe proves to be insufficient within the first week; the toe is cyanosed; cautious measures helping to keep it warm artificially should be administered to benefit its biologic processes. The first signs of restored sensibility appear only after several months have elapsed. Toes used for transplanting should always be taken from the same side of the body as the maimed finger. The highly irksome position in which the patients were obliged to remain for over a fortnight as a rule was borne fairly satisfactorily. In the case reported by Bier, Braun and Kümmel,[4] it was necessary to cut

the bridge on the tenth day following the operation, as the patient was no longer able to stand this artificial symbiosis between hand and foot. Notwithstanding an aseptic postoperative course, this resulted in necrosis of the toe. Therefore, an interval of 18 to 20 days between the first and second stages of the operation may prove a failure unless the toe is duly taken care of after it has been finally separated.

In Soviet surgery we have so far had one case of a plastic operation with the object of substituting a toe for a lost finger.

CASE REPORT.—Patient V. A., aged 23, entered the clinic February 22, 1930. She complained of a defect of the left index finger which was the result of a trauma received seven months previously. A worker at the shoe factory "Skorokhod," the patient had had her left wrist caught in a press, and as a result of the accident her left index finger had been amputated (Fig. 1).

February 26, Professor Wreden, R. R., performed an operation after Nicoladoni's method with the object of transplanting the second toe (Fig. 2). The postoperative period took a normal course. Soon after the removal of the plaster-of-Paris bandage the transplanted toe began to show signs of restored sensibility to pain and temperature, while sensibility to touch was restored in three months.

At present, three years since the operation, the motor activity of the transplanted toe is normal (Figs. 3, 4 and 5). The patient is able to lace and unlace shoes, undo knots, *etc.*, with the aid of the left index finger. Hence, the results obtained are excellent both from a functional and a cosmetic point of view.

REFERENCES

[1] Eiselsberg: Arch. für klin. Chir., Bd. 61, S. 988.
[2] Krause, F.: Berliner klin. Wchnschr., S. 1527, 1906.
[3] Nicoladoni: Arch. für klin. Chir., Bd. 61, S. 606, 1900.
[4] Bier, Braun, and Kümmel: Chir. Operationslehre, Bd. 5, 1929.

POSTOPERATIVE PULMONARY ATELECTASIS

REPORT OF ELEVEN CASES

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POSTOPERATIVE pulmonary atelectasis has been the subject of much study in the past ten years. It has been recognized as of frequent occurrence and as the underlying factor in most pulmonary complications of surgery. The broader knowledge of the whole subject has made available means for reducing the incidence of the condition and for effectively combating it, once it has developed.

Postoperative pulmonary atelectasis may be defined as that condition existing when a part or all of one or several lobes of the lung becomes collapsed and airless after, or at the time of, a surgical operation.

Incidence.—In a very carefully studied group of 456 cases Brunn and Brill[1] found pulmonary atelectasis demonstrable by roentgen ray in 4.8 per cent. The incidence varies with the diligence with which it is sought and the diligence with which prophylactic measures are enforced. In our series the incidence in abdominal operations was 2.49 per cent in 1931, 1.77 per cent in 1932, and only 0.77 per cent in 1933. The average was 1.59 per cent. The incidence in all operations was 0.86 per cent (Table A).

TABLE A

Statistics on Postoperative Pulmonary Atelectasis

Year	All Operations	Cases of Pulmonary Atelectasis	Abdominal Operations	Cases of Pulmonary Atelectasis
1931	394	6 (1.52 per cent)	201	5 (2.49 per cent)
1932	347	3 (0.86 per cent)	169	3 (1.77 per cent)
1933	535	2 (0.37 per cent)	260	2 (0.77 per cent)
Totals	1,276	11 (0.86 per cent)	630	10 (1.59 per cent)

Etiology.—Most observers[2, 3, 4, 5] now agree that the determining factor in the production of pulmonary atelectasis is bronchial obstruction by mucus. This factor was first recognized by William T. Gairdner,[6] of Glasgow. He appreciated both the ball-valve obstruction and the complete blockage types. In 1912, Elliott and Dingley[7] revived the mucous plug theory and were the first to emphasize its importance in postoperative atelectasis. Jackson and Lee,[5] in 1925, reported relief in a postoperative case by aspiration of a plug of mucus through the bronchoscope. Since then Lee and co-workers[8, 9, 10] have done much work on the subject. They have produced atelectasis in the

dog by obstructing a bronchus with the tenacious mucus obtained bronchoscopically from a patient suffering with postoperative pulmonary atelectasis. This was accomplished only after abolishing the cough reflex by sodium amytal given intraperitoneally. Some[11, 12, 13, 14] have felt that bronchial obstruction by mucus does not explain every case of postoperative pulmonary atelectasis. Massive collapse of both lungs[15] has occurred simultaneously with death of the patient, and the autopsy did not reveal any obstructive mucus. It has been suggested that some reflex stimulation of the vagus nerve might be responsible for the sudden collapse of a part or all of a lobe of the lung. It has been shown[16] that muscle tissue extends into the finest of the bronchi and bronchioles, perhaps to the alveoli themselves. However, no one has been able to produce atelectasis experimentally by reflex stimulation.

There are many predisposing factors. In 1918, Allen O. Whipple[17] made a very thorough study of postoperative pneumonitis. This was long before pulmonary atelectasis was generally recognized as the underlying factor in most pulmonary complications. Many of the 97 cases he reported would now be classified as pulmonary atelectasis. He discussed predisposing causes under the following headings: (A) Local inflammations in the upper respiratory tract and factors favoring them. (B) Vasomotor changes causing a congestion of the pulmonary vessels. (C) Factors inhibiting the normal thoracic and abdominal respiratory movements and favoring atelectasis and hypostasis in the lungs. (D) Local or general infections elsewhere than in the respiratory tract. (E) Debilitated states resulting in a lowered natural or acquired immunity to the particular organism inciting the pneumonia. (F) Factors increasing the virulence of the inciting organism. The first four of these groups cover most of the predisposing causes of pulmonary atelectasis as we view it today, and include important factors that have received little mention in recent reports. Subsequent work has elaborated, chiefly, the factors in group (C).

Churchill and McNeil[18] have noted the reduction in vital capacity following operation. This is much more pronounced after operation on the upper abdomen, and during the first day after operation may be but one-third of the preoperative volume. Muller, Overholt, and Pendergrass[19] have noted this, and also constant changes in roentgenographic findings following operation on the upper abdomen. Elevation and relative fixation of the diaphragm are always present. Transient, physical signs in the chest are frequently found. They have termed this condition pulmonary hypoventilation. Henderson[20] has attributed the changes to acapnia, a deficiency of carbon dioxide in the blood and tissues, arising from a disturbance of respiratory metabolism of the tissues, analogous to asphyxia.

Prinzmetal, Brill, and Leake[21] have demonstrated an increased intrapleural pressure following surgery, which they have shown to be due to anesthesia, abdominal incision, traction on abdominal viscera, and pressure on the abdominal wall. This, unquestionably, acts in lowering the vital capacity of the lung, and thus favors the accumulation of secretion. Morphine, sodium

amytal, and other sedatives tend to decrease the amplitude and rate of the respiratory excursions and to dull or abolish the cough reflex. Spinal anesthesia is often accompanied by a slow, shallow respiration. The importance of a diminished, or absent, cough reflex should be emphasized. Anesthesia, preoperative and postoperative medication, acapnia, pain, and shock may all contribute. Van Allen and Lindskog[22] have shown that cough loses its effectiveness as soon as the air has been absorbed from the obstructed lung. They have also shown that there are peripheral intercommunications between the branches of the bronchial tree, permitting the transfer of gases, fluids, and particulate matter. Hence, obstruction of any bronchus distal to the main lobe bronchus does not shut off all air to the part of the lung supplied by that bronchus, unless the intercommunicating channels are also blocked. This probably explains why pulmonary atelectasis does not occur more frequently.

It may be said, summarily, that all conditions which tend to reduce the vital capacity of the lung, or tend to increase the amount or viscosity of bronchial mucus, or hinder its expulsion, predispose to pulmonary atelectasis. Others would add factors predisposing to a reflex spasm of the bronchioles and bronchi.

Pathology.—The affected lung area is shrunken, airless, firm, gray in color, and sinks in water. The bronchi are often filled with a tenacious, densely adherent mucus. Microscopically, the alveolar walls are engorged with blood, and the alveolar spaces are flattened and small. They may contain an homogeneous mucoid substance and a variable amount of cellular exudate.

Symptoms and Signs.—In a typical case of severe, massive atelectasis the picture is that of a catastrophe. The onset is usually within 48 hours of operation, although it may occur long afterwards. There is usually a sudden elevation in temperature, pulse, and respiratory rate. The patient is usually dyspneic. He may be cyanosed. He may, or may not, attempt to cough. There is often severe pain in the chest or in the abdomen. The facies show anxiety. Expansion of the chest is limited or absent over the affected area. Often the interspaces appear retracted. Expansion on the opposite side may be increased. The apex beat of the heart may be seen to be displaced toward the lesion. In massive collapse of the right lung the heart may be entirely on the right side of the thoracic cage. Percussion will establish the position of the heart borders displaced to the side of the lesion. Early, there is often hyperresonance over the affected lung, but, as the bronchioles and alveoli become filled with secretion, dulness will be found. At first, the breath sounds are absent or diminished, and there are no râles. Later, as air again gains access, there may be tubular or amphoric breathing and moist crackling or bubbling râles. If the patient is turned on the unaffected side and carbon dioxide and oxygen are administered, he will usually begin to cough up a heavy, thick, tenacious, green sputum. The sputum is never bloody or rusty in color. In the course of a few minutes to many days the lung expands, the heart returns to normal position, and breath sounds can be heard over

the affected lung, with many moist râles. Dulness and coarse crackling râles may persist for many days after the lung reexpands.

By far the majority of cases of pulmonary atelectasis are less severe than the above. Most of them are not recognized unless the chest is thoroughly studied daily, or twice daily, following operation. Other cases will show slight temperature and pulse elevation, with or without cough. There may be little or no displacement of the heart, particularly where there is a small area of atelectasis in both lower lobes. The signs over the affected lung may be much the same as in the massive type, except that they are found only in small or scattered areas. Often the slight disturbance has been erroneously called a postoperative reaction.

Roentgenographic Findings.—In severe cases there are: elevation of the diaphragm on the affected side; narrowing of the chest on that side; increased obliquity of the ribs; narrowing of intercostal spaces; a displacement of the trachea, heart, and the mediastinum to the affected side; and a variable amount of shadow in the affected lung area. Early, there may be little or no increase in density over the lung; later, the shadow may be dense and homogeneous. Nearly all the papers on postoperative pulmonary atelectasis have reported extensive roentgenographic investigation of the cases reported. The roentgen ray, however, is not always essential in the diagnosis and treatment of this condition. Diagnosis can usually be made on the signs and symptoms and satisfactory treatment instituted. Where a portable roentgen ray unit is not available, it may be desirable not to use the roentgen ray. Due credit must be given the roentgenologists, whose good work has added so much to the knowledge of this subject.

Differential Diagnosis.—Dilatation of the stomach, ileus, peritonitis, pleuritis (with or without effusion), pneumonia, pulmonary embolism, cardiac failure, coronary thrombosis, and dextrocardia have all been erroneously diagnosed in pulmonary atelectasis. It is to be remembered that the first two may precede or may follow atelectasis. Pneumonia may follow, as may cardiac failure. Careful physical examination makes the diagnosis in the great majority of cases. Roentgen ray examination is of value in doubtful cases.

Following are brief reports of the cases of more or less severe postoperative atelectasis which we have recognized from 1931 to 1933.

Case Reports

Case I.—Mrs. A. L. F., aged 30, was admitted January 27, 1931. She had been in labor for twelve days. She had a mitral stenosis and insufficiency. Cesarean section was performed under spinal anesthesia. The first 24 hours after operation were uneventful and unusually comfortable. Thirty hours after operation she was given one-sixth grain of morphine by hypodermic. At this time the pulse was 120, while a short time before it had been 84. At 36 hours the temperature was 103°, the pulse 138, and the respirations 34. She was extremely dyspneic and cyanotic. Expansion was limited on the right, good on the left. The cardiac impulse was palpable to the right of the sternum, the apex beat just a little inside the left, midclavicular line. There were some dulness and absence of breath sounds in the right axilla. Oxygen, 90 per cent, and carbon dioxide, 10 per cent, were administered, and the patient was placed on the

left side. She showed some immediate improvement, but did not cough up anything. Seventy-two hours after operation it was noted that the respiratory rate was normal, there were a few coarse râles in the right axilla, and the heart had returned to a normal position; but the temperature and pulse rate were still elevated, and abdominal distention was increasing. The distention resisted all treatment, the heart dilated, and death occurred five days after operation. Permission for an autopsy was not obtained. It was our opinion that the collapse of the right lung was relieved, but that it initiated a cardiac failure, leading to death.

CASE II.—Mrs. H. B., aged 27, had a mitral stenosis and insufficiency. Sixteen hours after appendectomy, under spinal anesthesia, she began coughing, and developed pain in the chest, dyspnea, and cyanosis. Two hours later she coughed almost continuously for twelve minutes and expectorated a great deal of mucus. She was seen just after this and was still slightly cyanotic. The pulse was 130. The right border of the heart was three inches to the right of the sternum; the apex beat was just inside the left, midclavicular line. The breath sounds were obscured by coarse rhonchi and bubbling râles all over the chest. The patient said she had a great deal of mucus that she could not cough up. She was turned on the left side and given one one-hundredth grain of atropine sulphate. Temperature at this time was 100 3/5°; the respirations 30. The patient was also started on tincture of digitalis by mouth. Thirty-six hours after operation the pulse had dropped to 108, respirations to 28; temperature 100 4/5°, and the chest was clear of râles. The heart had returned to normal position, the right border being in the midline and the apex beat in the left axillary line. The temperature and pulse gradually fell, reaching normal five days after operation. This patient received three grains of sodium amytal and one-sixth grain of morphine sulphate three hours after operation. From then until the development of the atelectasis she was fairly comfortable and sleeping most of the time.

CASE III.—J. A., male, aged 21, had an appendectomy under spinal anesthesia. Thirty-four hours after operation he coughed up some green mucus. The temperature reached 103 4/5°, pulse 140, respirations 44. There was some hyperresonance in the left axilla, and breath sounds were distant over the entire left lung. The heart and mediastinum were displaced to the left. When placed on the right side he coughed up more green, thick mucus. Twenty-four hours later he was very much improved; the temperature and pulse practically normal, and the heart almost back to normal in position. He was still coughing, and a few coarse crackles could be heard in the left axilla. The next day the chest was normal. This patient had one-sixth grain of morphine sulphate and three grains of sodium amytal just before operation and another one-sixth shortly thereafter. He slept most of the time following the operation, until the development of the atelectasis, although he had but one more dose of morphine.

CASE IV.—E. G. W., male, aged 37, had a repair of a traumatic hernia three hours after the injury. His convalescence was marked by an unusual amount of pain. Early in the morning of his sixth postoperative day the temperature reached 101 2/5°; pulse 98. He had had a slight cough for 24 hours. The cough became more severe, and he expectorated some greenish mucus. There was some dulness in the left axilla, and there were a few crackling râles, but no appreciable displacement of the heart. He was turned on his right side. In two days the dulness had disappeared; there was still a slight cough; there were no râles. The slight cough persisted two more days. This patient received a grain of codeine a few hours before the development of the atelectasis.

CASE V.—T. M. K., male, aged 57, had an amputation through the right thigh for dry gangrene of the foot. For four weeks previous to the operation he had received huge doses of morphine for pain in the right leg and foot. He was given one-half grain of morphine sulphate before the operation, which was performed under a spinal anesthetic. In the first eight hours following operation he was given one and one-half grains of morphine sulphate to control severe spasms of pain in the right thigh and

lower abdomen. Eight hours after operation he developed an acute dilatation of the stomach. At the same time it was noted that the apex beat of the heart was lateral to the left anterior axillary line, and the right border of the heart was to the left of the sternum. There was hyperresonance in the left axilla, and no breath sounds were heard. Respirations 41; pulse 88; temperature 99 4/5°. The stomach was evacuated and the patient turned a little on the right side. Carbon dioxide and oxygen had already been administered twice following operation and had been given the patient throughout the operation. Following development of the atelectasis they were given at frequent intervals, until the time of his death, which was 24 hours after operation. Pulse and temperature both continued to increase, the temperature reached 106°. He developed a generalized, pulmonary edema before death.

Postmortem Findings.—Thorax.—The heart was greatly displaced to the left, the apex being in the midaxillary line and the right border to the left of the sternum. Both pleural cavities were completely obliterated by old adhesions. The lower lobe of the left lung was about seven and one-half cc. in diameter and contained no air. The bronchus of this lobe was filled with a thick, tenacious secretion, which adhered firmly to the wall. There were no areas of consolidation in the right lung. The heart was enlarged and dilated. There was some organized blood clot in the left auricle, in addition to the postmortem clot. The mitral valve was greatly thickened, and the leaflets were somewhat distorted. The coronary vessels showed considerable thickening. The right femoral artery was filled with an organized clot up to the level of Poupart's ligament; a thrombus was present in the left popliteal artery. Gross pathologic diagnosis: embolus right femoral artery, left popliteal artery, amputation right leg above the knee, myocardial hyertrophy and dilatation, mitral insufficiency, coronary artery sclerosis, massive pulmonary collapse of left lower lobe, chronic pleural adhesions. Microscopic examination of the collapsed lobe of the lung revealed small, flattened, alveolar spaces filled with a homogeneous substance taking a pale eosin stain. A few leukocytes and erythrocytes were present in the alveoli. The alveolar walls were thickened, and the capillaries were distended with blood.

Case VI.—W. T. C., female, aged 64, had a cholecystectomy and appendectomy under spinal anesthesia. Seventy-two hours after operation the pulse rose to 120 and the respirations to 50. There was slight abdominal distention; some cyanosis; limited expansion over the right lower chest; and some dulness in the right axilla, with distant tubular breath sounds and a few crackling râles. She was turned on the left side. Twenty-four hours later the temperature and pulse were practically normal, expansion of the chest was symmetrical, and there were no râles. She had a very prolonged and stormy convalescence. No further pulmonary complications developed until one month after operation, when after having been up three or four days, she developed fever and pain in the left lower chest. In 24 hours there was dulness all over the left base, with blowing breath sounds and many crackling râles. The temperature came down to normal in a week, with gradual clearing of the chest signs. This may have been an atelectasis, but was probably a pneumonia. This patient also had a chronic myocarditis and marked hypertension. Auricular fibrillation was present at intervals during her stay in the hospital.

Case VII.—W. O. McD., female, aged 46, had a cholecystectomy and appendectomy under spinal anesthesia. She received one-fourth grain of morphine sulphate and three grains of sodium amytal before operation and frequent doses of morphine afterward. Within 12 hours after operation her temperature rose to 102°, pulse 106, and dyspnea developed. Twenty-four hours after operation dyspnea was still present, the heart was displaced a little to the right, and breath sounds in the right axilla were distant. Postural treatment was instituted and one-half ounce of whisky prescribed, t. i. d. Temperature gradually fell to normal over a period of five days. This patient had very little cough, but some expectoration of the characteristic mucus.

Case VIII.—J. C., female, aged 12, had an appendectomy and drainage under

ether anesthesia. Preoperative medication consisted of morphine sulphate, one-eighth grain, atropine sulphate, one one-hundredth-fiftieth grain. Twenty hours after operation the temperature reached 105°, axillary; respirations 40, with some cyanosis. There seemed to be a great deal of mucus in the trachea. Expansion was greatly limited on the right. The right border of the heart was displaced one inch to the right of the sternum. Breath sounds were blowing, with loud, bubbling râles over the right, lower lobe. The patient was placed on her left side, and carbon dioxide and oxygen were given intermittently by nasal catheter. She was given whisky two drams every four hours. She immediately began expectorating a thick mucus, green in color. Each dose would stimulate cough and expectoration. Cough and expectoration continued for five days. At the end of this time temperature and pulse were normal and physical examination of the chest was negative. This patient received three small doses of morphine following operation and slept most of the time until atelectasis developed.

CASE IX.—Mrs. P. A. W., aged 25, had a cholecystectomy and appendectomy under spinal anesthesia, for acute cholecystitis and cholelithiasis. She received morphine before and after operation in liberal doses. Ten hours after operation the temperature was 103°, pulse 120, respirations 48. The respiratory excursion was very shallow, but there were no abnormal findings over the lungs, and the cardiac position was normal. Forty-eight hours after operation the heart was found displaced a little to the right, and breath sounds at the right base were distant. The respirations remained at 40 to 60 for 15 days after the operation. There was slight fever for 12 days, with a little elevation of pulse. During this time the patient coughed a little and expectorated a great deal of thick mucus. She did not feel or appear ill, except for the rapid respiratory rate. A roentgenogram 11 days after operation showed a high diaphragm on the right side, with a dense shadow in the right lower lobe. This patient was given carbon dioxide and oxygen during operation and at intervals of three hours for 48 hours after operation, then four times daily for another week. During this time her position was changed at frequent intervals.

CASE X.—Mr. E. R. D., aged 36, had a bilateral, inguinal hernia of such size that the scrotum hung at least ten inches below the inguinal ring and was ten inches in diameter. The right side alone was repaired at the first operation. Twenty-four hours after operation he was very uncomfortable and had mucus in his throat, but would not cough. Thirty hours after operation he became cyanotic, and the pulse was rapid and weak. The right side of the chest was almost immobile; the right border of the heart was in the right nipple line, and the left border in the left parasternal line. Breath sounds were absent over the entire right chest. He was given carbon dioxide and oxygen and turned on his left side. In the evening he started coughing up a thick, green sputum. Forty-eight hours after operation the pulse rate was down to approximately normal, the heart was back to normal position, and there were a few coarse crackling râles in the right axilla. He continued to cough up considerable sputum for another 48 hours.

CASE XI.—Mrs. J. S., aged 29, was admitted to the hospital December 23, 1932. She was coughing frequently, was slightly cyanotic and dyspneic, and the abdomen was distended to the size of a full-term pregnancy. Expansion was limited over the left lower chest. There was some dulness to percussion beneath the left scapula, with distant, harsh, blowing breath sounds and squeaking and crackling râles. The right lung was clear. The apex beat of the heart was well outside the left midclavicular line, and the right border was beneath the sternum. The patient complained of a cold in the head, cough, and pain in the left chest. The temperature was 100°, but fell to normal in 24 hours. The pulse rate remained about 100 throughout her stay in the hospital. The signs at the left base persisted. The patient was dismissed after 48 hours. For the next two weeks she was up and about at home. Some cough and signs of partial collapse at the left base persisted. At 2 A.M., January 8, 1933, the patient was awakened by pain in the right lower abdomen and nausea, and was again

admitted to the hospital. At this time the heart was still displaced to the left. At the left base, posteriorly, there was dulness, with distant tubular breath sounds and loud coarse crackling râles. The right lung was clear. There were acute tenderness and some rigidity in the right iliac fossa. Cesarean section and appendectomy were performed under spinal anesthesia. Convalescence was marked by considerable abdominal pain, and the complaint of mucus in the throat, which could not be expectorated. Seventy-two hours after operation acute dilatation of the stomach developed. Accompanying this there were slight dulness at the left base, limited expansion, distant blowing breath sounds, and coarse crackling râles. The stomach was evacuated and the patient turned on the right side. In 48 hours the lungs were normal to physical examination.

Comment.—An analysis of these 11 cases is interesting. Four patients had heart disease, and in three of these a mitral lesion was present. Two patients in the group had syphilis. In nearly every case the patient was either unusually comfortable from medication given preoperatively, or he was suffering severe pain, for which large and frequent doses of morphine were given. In seven of the cases atelectasis developed within the first 36 hours. Case VIII, aged 12, was convalescing from a cold and had a slight cough at the time of the appendectomy.

There were three cases following appendectomy, three following cholecystectomy, two following cesarean section, two following herniorrhaphy, and one following amputation through the thigh. Spinal anesthesia was used in ten of the cases, ether in one. This apparently shows a much higher incidence after spinal anesthesia. However, in abdominal operations we have used spinal anesthesia five times as often as ether, and it has been our policy to urge spinal anesthesia upon patients whom we considered poor risks, while ether, in most instances, has been used only in those cases where no trouble was expected.

There were two deaths. Both of these patients had heart disease, and both a mitral lesion. It can be stated with reasonable assurance that Case I would not have died had she not developed a pulmonary atelectasis. How much pulmonary atelectasis contributed to the fatal outcome in Case V is debatable. Both cases died with a myocardial failure.

Six of these cases occurred in 1931, including the two deaths, three occurred in 1932, two in 1933. The last two, Cases X and XI, had conditions tending to elevate the diaphragm, one a pregnant uterus, the other an increased intra-abdominal tension from a reduction of a large hernia. In the first of these the collapse was present before operation.

Table A shows the reduction in incidence during the three years. This reduction coincided with the institution of prophylactic measures. Beginning with 1932 carbon dioxide, 10 per cent, and oxygen, 90 per cent, have been administered to many of the patients. This method was first suggested by Yandell Henderson[20, 23] and since has been recommended by others as a prophylaxis against pulmonary atelectasis. We have used it routinely during all spinal anesthesias. Carbon dioxide, 10 per cent, and oxygen, 90 per cent, have been given postoperatively to most patients taking ether anesthesia.

They have been given at intervals after operation in those cases deemed most likely to develop atelectasis. A copious flow of the mixed gases has been administered through an open cone held close to the patient's face. In a personal communication Dr. Walter Estell Lee has suggested that the carbon dioxide and oxygen should be given through a closed mask, and be rebreathed into a bag. He states that 8 to 15 inhalations rebreathed into a closed rubber bag will make anybody cough following the hyperventilation induced.

Another important factor in this reduction in our cases revolves about preoperative and postoperative medication. For the past two years we have given three grains of sodium amytal the night before, but none the morning of operation. The size of the dose of morphine has been reduced.

Prophylaxis.—After a consideration of the literature and the above clinical data, the following program is suggested:

(1) Postoperative pulmonary atelectasis should be anticipated and every effort made to avoid its occurrence: in patients with inflammation of the respiratory tract, including that induced by ether anesthesia; in patients with heart disease; in debilitated patients; in very sick and drowsy patients; and in patients with factors promoting increased abdominal tension. It is to be remembered that local and spinal anesthesia, apparently, do not decrease the incidence of pulmonary atelectasis.

(2) Large doses of morphine and other sedatives before and after operation should be avoided.

(3) On the operating table, pressure on the patient's chest by instruments, assistants, *etc.*, should be avoided. Operating time should be as brief as possible.

(4) Carbon dioxide, 10 per cent, and oxygen should be administered at intervals during all spinal anesthesia to avoid acapnia with its tendency to nausea and decreased vital capacity.

(5) Carbon dioxide and oxygen should be administered for five minutes at the end of all local and general anesthesia.

(6) Carbon dioxide and oxygen should be administered for five minutes, three or four times daily, for at least 48 hours following all abdominal operations, and after other operations when there is any possibility of atelectasis taking place.

(7) The patient's position should be changed every three or four hours after operation.

(8) Deep breathing at frequent intervals should be encouraged.

(9) Dilatation of the stomach should be avoided by using the nasal tube at the first indication of gastric distention.

Treatment.—All 11 of our cases were treated by the postural method recommended by Sante in 1927.[14, 24] This consists in rolling the patient back and forth on the uninvolved side. Percussion over the involved lung facilitates the expulsion of mucus. The patient should not be left in this position for long at a time, as atelectasis may then develop in the other lung

Carbon dioxide and oxygen are used therapeutically as well as prophylac-

tically. They induce deeper breathing and probably a widening of the lumina of the bronchi and bronchioles. They should be employed only in conjunction with the postural method of treatment. If they are administered with the patient lying on the affected side, it may lead to firmer incarceration of the obstructing mucus.

Whisky, undiluted, will often stimulate cough and expectoration when posture and carbon dioxide fail.

Before the postural treatment was introduced by Sante, the only direct way of attacking atelectasis was by bronchoscopic aspiration of the obstructing mucus. The use of this method in a postoperative case, as previously mentioned, was first reported by Chevalier Jackson and Walter Estell Lee. Lee, and Jackson's associates, Clerf and Tucker, subsequently reported a number of cases successfully treated in this manner.[25, 26, 8] When posture, carbon dioxide, and whisky do not produce the desired result, bronchoscopy is to be considered, if one skilled in the use of the bronchoscope is available.

CONCLUSIONS

A knowledge of factors predisposing to the development of postoperative pulmonary atelectasis is of great importance in its prevention.

A number of these factors have received little attention in recent reports.

The reduction in incidence of this complication in our cases in the past two years demonstrates the value of recognizing predisposing causes.

The roentgen ray is not always essential to diagnosis and treatment.

The plan outlined for prophylaxis should make postoperative pulmonary atelectasis a negligible factor in surgical morbidity and mortality.

REFERENCES

[1] Brunn, H., and Brill, S.: Observations on Post-operative Pulmonary Atelectasis. ANNALS OF SURGERY, vol. 92, pp. 801–837, 1930.

[2] Lee, W. L.: Postoperative Pulmonary Complications. ANNALS OF SURGERY, vol. 79, pp. 506–532, 1924.

[3] Dyke, C. G., and Sosman, M. C.: The Postural Treatment of Post-operative Massive Atelectatic Collapse. Surg., Gynec., and Obstet., vol. 49, pp. 752–763, 1929.

[4] Coryllos, P. N.: Post-operative Pulmonary Complications and Bronchial Obstruction. Surg., Gynec., and Obstet., vol. 50, pp. 795–827, 1930.

[5] Jackson, C., and Lee, W. E.: Acute Massive Collapse of the Lungs. ANNALS OF SURGERY, vol. 82, pp. 364–389, 1925.

[6] Quoted by Bowen, D. R.: Acute Massive Collapse (Atelectasis) of Lung. Am. Jour. Roentgenol., vol. 21, pp. 101–141, 1929.

[7] Quoted by Lee.[2]

[8] Lee, W. E., Tucker, G., and Clerf, L.: Post-operative Pulmonary Atelectasis. ANNALS OF SURGERY, vol. 88, pp. 6–14, 1928.

[9] Lee, W. E., Ravdin, I. S., Tucker, G., and Pendergrass, E. P.: Studies on Experimental Pulmonary Atelectasis. ANNALS OF SURGERY, vol. 88, pp. 15–20, 1928.

[10] *Idem.:* Experimental Atelectasis. Arch. Surg., vol. 18, pp. 242–256, 1929.

[11] Scott, W. J. M.: Post-operative Massive Collapse of the Lung. Arch. Surg., vol. 10, pp. 73–116, 1925.

[12] Scott, W. J. M., and Joelson, J. J.: Post-operative Massive Atelectasis. Arch. Surg., vol. 15, pp. 855–870, 1927.

[13] Scott, W. J. M., and Cutler, E. C.: Post-operative Massive Atelectasis. J.A.M.A., vol. 90, pp. 1759–1763, 1928.

[14] Sante, L. R.: Massive (Atelectatic) Collapse of the Lung, with Especial Reference to Treatment. J.A.M.A., vol. 88, pp. 1539–1542, 1927.

[15] Sante, H. E.: Bilateral Massive Collapse of Lung. Transactions of the New York Surgical Society. ANNALS OF SURGERY, vol. 85, pp. 608–610, 1927.

[16] Macklin: Quoted by Henderson.[21]

[17] Whipple, A. O.: A Study of Post-operative Pneumonitis. Surg., Gynec., and Obstet., vol. 26, pp. 29–47, 1918.

[18] Churchill, E. D., and McNeil, D.: The Reduction in Vital Capacity Following Operation. Surg., Gynec., and Obstet., vol. 44, pp. 483–488, 1927.

[19] Muller, G. P., Overholt, R. H., and Pendergrass, E. P.: Post-operative Pulmonary Hypoventilation. Surg., Gynec., and Obstet., vol. 18, pp. 1322–1345, 1929.

[20] Henderson, Y.: Acapnia as a Factor in Post-operative Shock, Atelectasis and Pneumonia. J.A.M.A., vol. 98, pp. 572–575, 1930.

[21] Prinzmetal, M., Brill, S., and Leake, C. D.: Post-operative Pulmonary Subventilation. Surg., Gynec., and Obstet., vol. 56, pp. 129–136, 1933.

[22] Van Allen, C. M., and Lindskog, G. E.: Collateral Respiration in the Lung. Surg., Gynec., and Obstet., vol. 53, pp. 16–21, 1931.

[23] Henderson, Y.: The Physiology of Atelectasis. J.A.M.A., vol. 93, pp. 96–98, 1929.

[24] Sante, L.: Massive (Atelectatic) Collapse of the Lung. ANNALS OF SURGERY, vol. 88, pp. 161–177, 1928.

[25] Hearn, W. P., and Clerf, L. H.: Post-operative Massive Collapse of the Lung. ANNALS OF SURGERY, vol. 85, pp. 54–60, 1927.

[26] Scheffey, L. C., Jones, H. W., and Clerf, L. H.: Post-operative Collapse of the Lung (Atelectasis) in Gynecologic Cases. Am. Jour. Obst. and Gynec., vol. 19, pp. 795–805, 1930.

GANGLIONECTOMY FOR HYPERHIDROSIS

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THE secretion of sweat is under the control of the nervous system. It can be produced in the feet of animals by stimulating the peripheral end of the cut sciatic nerve even after occlusion of the aorta and amputation of the extremity. In man very little is definitely known of the nervous mechanism involved. The existence of cortical centers is indicated by the fact that profuse perspiration frequently occurs as a consequence of emotional states. The work of neuro-physiologists[3, 4] indicates that the cortex and brain stem exert controlling influences on the sweat centers of the spinal cord in animals. There is evidence to show that this influence is predominately inhibitory.[2, 3] The spinal centers for sweating are apparently scattered throughout the length of the cord, probably in the ventral horns of the gray matter. They are in close proximity to the somatic motor cells and to the spinal centers for vasoconstriction. From their cells of origin the fibers for sweating leave the cord with the anterior roots and pass along the white rami communicantes to the sympathetic ganglia. Fibers from the cells of these ganglia pass by way of the gray rami communicantes to the spinal nerves and finally to the sweat glands. The fibers for vasoconstriction parallel those for sweat. Both are widely distributed as components of the peripheral spinal nerves, and supply areas practically identical with the cutaneous sensory distribution. By freeing certain sympathetic ganglia of their connecting rami and by removing the trunk which bears these ganglia, total inhibition of sweating can be produced in certain areas of the body without fear of sensory or motor loss.

It is not the purpose of this paper to discuss the factors which influence the secretion of sweat. It is sufficient to point out that the amount of sweating varies greatly in normal individuals, and under many different conditions. It may be increased to such an extent that it is definitely abnormal. Profuse perspiration may be the source of much annoyance, embarrassment and mental anguish, especially if it emits an unpleasant odor. Even though only moderately increased in amount, the odor or color of perspiration may be offensive. Certain substances may be excreted in the sweat which spoil materials on which the individual works, thus interfering with his occupation, as for example, in bromidrosis the sweat affects metals. Abnormal sweating may be the main etiologic factor in certain skin diseases, which involve primarily the extremities. When conditions of sweating occur which interfere with the health, occupation and peace of mind, or the continued happy existence of an individual, and if conservative measures give no relief, surgery is indicated. Sympathetic ganglionectomy at the proper level will

produce a total inhibition of sweating in the desired regions (Fig. 1). Whenever anhidrosis is thus produced, there occurs vasomotor paralysis in the identical areas of distribution, as evidenced by rise of surface temperature. It is impossible to influence separately the fibers for sweating and those for vasoconstriction by surgical means; but this accompanying release of normal vasoconstriction gives no uncomfortable symptoms.

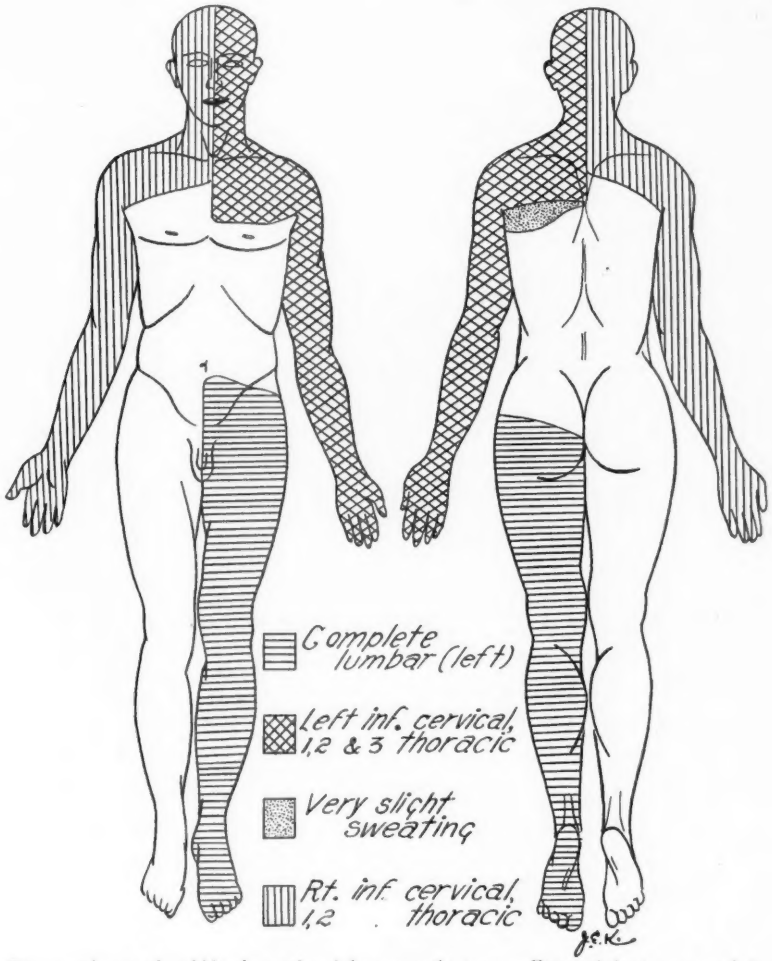


FIG. 1.—Areas of anhidrosis produced by sympathectomy. External heat was used to delineate the affected areas.

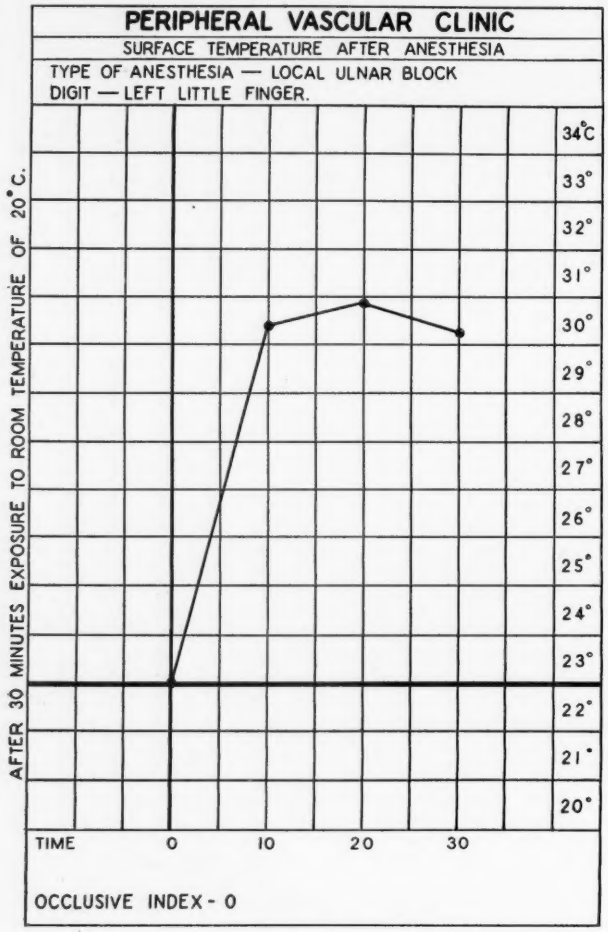
CASE REPORT

An unmarried Jewess, 22 years of age, presented herself at the Sympathetic and Vascular Clinic of Mount Zion Hospital November 28, 1933, complaining of marked perspiration of the hands and feet since she was eleven years old. Her hands were often cold and blue, especially in cool weather. The sweating was worse when she was nervous, or when she worked at her usual employment as a candy maker. In the past few years the perspiration had increased to such an extent that it interfered with her occupation. She constantly carried a handkerchief in her hand to absorb the excess sweat, and suffered

much embarrassment and mental anguish in her social life. Her feet were involved to a much less extent than her hands. There were never any attacks of local syncope.

On examination of the hands one noted that there was a moderate diffuse cyanosis of the digits, worse at the acra. There was a profuse sweating of both hands extending to the wrists, worse at the skin folds and on the palmar surfaces. Large drops of sweat fell from the outstretched hands. The sweat was clear, colorless and odorless. When the hands were immersed for ten minutes in water at 16° C., there was a marked blotchy

ABNORMAL SWEATING OF THE EXTREMITIES



Graph showing normal vasodilatation response to ulnar nerve block. The anesthestic area became dry, pink and warm.

cyanosis, worse at the finger tips, due to precapillary arteriospasm. All palpable arteries had normal pulsations. The feet presented a similar, but less marked picture. The sweating was present to the ankle. All arterial pulsations of the feet were normal. The clinical diagnosis was "sympathetic imbalance, vasoconstriction type, with abnormal hyperhidrosis." For three months she was treated with tissue extract subcutaneously, diathermy to the cervicodorsal spine, faradic stimulation, and nerve sedation with the hope of diminishing sympathetic activity without result.

On February 24, 1934, both hands were exposed for one-half hour to a constant temperature of 17.2° C. and skin temperatures measured with the Tycos thermocouple.

The left ulnar nerve was then blocked with novocain at the elbow. There was prompt anesthesia confined to the ulnar distribution, with total absence of sweating and prompt rise of surface temperature to the normal vasodilatation level (Graph). The anesthetized zone was bright pink with vasodilatation in contrast to the cyanotic appearance of the

FIGS. 2, 3, 4 and 5.—Results of left cervicothoracic ganglionectomy. Sweating was produced by the application of external heat. Fine charcoal was then blown on the face, upper thorax and hand, which adhered to the moist areas but not to the anhidrotic surfaces. The Horner complex is noticeable.

unanesthetized areas. This confirmed our clinical impression that we were not dealing with vascular occlusion, but purely with spasm.

In April, 1934, after five months of continuous conservative therapy had given no relief, the patient was advised that she could be relieved by sympathetic ganglionectomy

and trunk resection. She elected surgical treatment, and April 8, 1934, operation was performed by one of us (F. L. P.). The left inferior cervical, first, second and third thoracic sympathetic ganglia were exposed by a posterior muscle splitting approach, freed of all connecting rami, and the trunk removed from above the inferior cervical to below the third thoracic ganglion. There was an immediate rise of surface temperature of the left upper extremity, to the normal vasodilatation level, and a complete absence of sweating of the left upper extremity and the homolateral half of the head, face, and upper thorax, anteriorly and posteriorly (Figs. 2, 3, 4, and 5). The Horner complex was present. The rise of surface temperature and the absence of sweating persisted in the areas affected until the present time, fourteen months after operation. It was noted that the amount of perspiration of the unaffected regions was greater than before operation. The delineation of areas of anhidrosis was obtained by the applications of external heat. Pilocarpin acts by stimulating the nerve endings, and its use might give erroneous information.

August 3, 1931, through an approach similar to that used on the left side, cervicodorsal ganglionectomy, ramisection, and trunk resection was carried out on the right side to the same extent as on the left. The result previously described for the left side became bilateral.

At the present time, fourteen months after the first operation, and ten months after the second operation, anhidrosis persists in the affected areas. The patient is well pleased and suffers no inconvenience from the complete loss of perspiration of the head, arms, and upper thorax. Complete vasodilatation has persisted, although the skin temperature is higher on the more recently operated side. Sweating below the area involved is definitely increased over the preoperative amount. This has been previously noted by us in four additional cervicodorsal sympathectomies performed for other conditions. In a case of hyperhidrosis reported by Adson[1] and treated by sympathectomy, a decrease of sweating was noted below the level of anhidrosis. We cannot account for this in view of our previous experience. One would naturally expect an increase in the per unit area of sweating in the unaffected zone.

It is too early to judge whether this artificial surgical anhidrosis is permanent. In cats it has been found by using an electrical skin resistance method that the absence of sweating after sympathectomy is not permanent, the glands resuming their normal activity after many months.[4] In about 45 days, however, there was a great fall in skin resistance to one-seventh of the maximum. In the case here reported, there has been no perceptible evidence of sweating even after long exposure to external heat, fourteen months after operation. One hesitates to apply to humans conclusions based on animal experimentation; and again there may be other factors which alter skin resistance so that the latter may not be a true measure of the degree of sweating. Nothing but clinical examination in humans can give a definite idea as to the permanency of anhidrosis induced by sympathectomy.

SUMMARY

There are instances when sweating which is abnormal in amount, color, odor, or chemical composition calls for surgical interference.

Sympathetic ganglionectomy and trunk resection will produce complete absence of sweating in certain definite regions, depending upon the ganglia removed.

A case is reported in which complete relief from excessive sweating was obtained following sympathetic ganglionectomy and trunk resection.

REFERENCES

[1] Adson, A., and Brown, G.: Extreme Hyperhidrosis of the Hands and Feet Treated by Ganglionectomy. Proc. Staff Med., Mayo Clinic, vol. 7, p. 394, 1933.

[2] Head, H., and Riddoch, G.: Reflex Conditions in Gross Injuries of the Spinal Cord. Brain, vol. 40, p. 187, 1917.

[3] Langworthy, O. R., and Richter, C. P.: The Influence of Efferent Cerebral Pathways upon the Sympathetic Nervous System. Brain, vol. 53, p. 178, 1930.

[4] Richter, C. P., and Shaw, B.: Complete Transection of the Spinal Cord at Different Levels: Their Effect on Sweating. Arch. Neurol. Psychiat., vol. 24, p. 1107, 1930.

SPLANCHNIC NERVE SECTION IN JUVENILE DIABETES

II. TECHNIC AND POSTOPERATIVE MANAGEMENT

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IN A previous article,[1] it was stated that the severe type of juvenile diabetic with unstable tolerance, one that has been diabetic for at least two years and adequately controlled for several months before the proposed operation, and one that shows no detectable vascular damage by films of peripheral vessels and ophthalmoscopy, is the type in which an operative procedure to improve carbohydrate metabolism could be undertaken with any justification. The experimental work serving as a basis for this operation has been described elsewhere.[2, 3] In addition, two tests were described for the selection of the proper case, the test for insulin-sensitivity and the test for ergotamine response after a galactose-hyperglycæmia.[1] The first test separates the insulin-sensitive from the insulin-resistant cases. As splanchnic-nerve section produces increased sensitivity to insulin,[2] only the insulin-resistant diabetic can derive any benefit from splanchnic-nerve section. The second test, briefly referred to as the galactose-ergot test, serves to indicate the effect of a sympathico-adrenal exclusion on carbohydrate metabolism. Should this test show a marked suppression of the galactose-hyperglycæmia by ergot, it augurs well as to the effect of splanchnic section. This was shown to be true by comparing such tests before and after operation. When the diabetic does not respond to ergot, a sympathetic depressant, nothing can be expected from splanchnic-nerve section.

When the juvenile or adolescent diabetic conforms to these requirements, one other point deserves serious consideration: Is there any evidence of tuberculous infection in the lungs or elsewhere? Tuberculosis in diabetics has recently received a thorough statistical investigation in a series of important articles by Howard Root.[4] Because of insufficient attention to this complication, one patient afflicted with latent or arrested tuberculosis has been subjected to operation. And while no harm seemed to have occurred as a result of surgery, the evaluation of the obtained result must necessarily have suffered.

Pre-operative Management.—The patient is under the continuous supervision of a competent internist before and after the operation. The urine is free or practically free from sugar, there is absence of acetone bodies in the urine, and lastly the blood sugar is around 180 milligrams or less. The diet contains 120 or more Gm. of dextrose a day to insure adequate glycogen storage in the liver. It is advisable to keep the patient from eight to ten days in the hospital before the operation to insure complete diabetic control and also to train the nursing service for their important help in post-operative

management. This consists of the examination of at least three daily specimens of urine during the day for sugar and diacetic acid, as the post-operative administration of insulin will depend primarily on the urinary specimens. Any student-nurse can be delegated to this task. Experience has shown that if internes or the main laboratories of large hospitals run these specimens, they will not be reported in time. As the nurses give the insulin and give it according to the urinary findings, it is logical to entrust them with these tests. Several days before the operation they are made to obtain these specimens, run them and report them on a special sheet. I attribute to these seemingly minor details the fact that operations which exposed the posterior mediastinum or the retroperitoneal spaces have all healed by primary union in spite of the presence of severe diabetes. On the morning of the operation, the patient receives a small dose of dextrose, say 200 cubic centimetres of unsweetened orange juice, which is covered with ten units of insulin.

Premedication and Anæsthesia.—The night before the operation a mild barbituric sedative, such as three grains of sodium amytal, is given not earlier than 9 P.M. In the morning this dose is doubled one hour before operation. In larger children, this morning dose may well be six grains of sodium amytal; in smaller children the dose should not exceed three grains. One-half hour before operation, morphine, gr. 1/6 with atropine, gr. 1/150 is given subcutaneously.

While the operation could be performed entirely under local anæsthesia, the anxiety and apprehension of these patients do more harm than the small dose of gaseous anæsthetic. Besides, the vicinity of and possible injury to the pleura may necessitate positive pressure. We begin, then, with a light ethylene anæsthesia and perform a paravertebral block of the ninth, tenth, and eleventh dorsal segments, together with a copious infiltration of the skin, subcutaneous tissues and paravertebral muscles along the incision, to be described presently. The syringe is kept full during the operation, and the intercostal nerves, the thoracic sympathetic trunk, the splanchnic nerves and the pleura are injected when exposed, not only to minimize the amount of general anæsthetic, but to block important reflexes, which may originate from the posterior mediastinum and which can produce shock.

Technic of the Operation.—Resection of the splanchnic nerves, while a much-used experimental procedure, has not been performed often in man. Most of the work has been carried out on cadavers, and transpleural,[5] supradiaphragmatic,[6] inframediastinal,[7] and infradiaphragmatic[8] approaches have been worked out. Of these, after considerable study on the cadavers, the supradiaphragmatic approach of Pieri,[6] which is nothing else but a typical posterior mediastinostomy, has been selected. After I had done four of these operations on man, the important anatomico-surgical study of Craig[9] became known. He modified Pereira's infradiaphragmatic approach. This operation consists of a posterior approach to the retroperitoneal space just below the diaphragm, utilizing a longitudinal incision about six centimetres away from the spinous processes, and was successfully carried out by Craig eight times.

The transverse "intersegmental" incision of Härtel,[10] however, gives in my experience a better exposure of the retroperitoneal space in the upper abdomen. Recently, the excision of the aorticorenal ganglion was performed without any difficulty by Härtel's approach. Up to date, however, all splanchnic-nerve sections for diabetes, six in number, were undertaken by the supradiaphragmatic approach, which will now be described in detail. With increasing experience, the operation necessarily underwent certain modifications.

The patient is in a semilateral position. A paravertebral incision is made, four fingers from the mid-line, starting at the level of the angle of the scapula and curving laterally over the tenth rib or tenth intercostal space for a distance of five to six centimetres (Fig. 1, insert A). This lateral curve, while not necessary, has facilitated the resection of longer segments of ribs. With the help of a kidney rest and elevation of the arm above the head, separation of the ribs is obtained. The incision transects the long muscles of the back and exposes the tenth and eleventh ribs, which are subperiosteally resected for a length of about six centimetres, approaching the mid-line as close as possible. In order to facilitate the approach to the lateral surface of the vertebræ, the intercostal vessels are doubly ligated and cut. The intercostal nerves may be preserved but can also be transected without any harm. The distal stump of the tenth nerve is transfixed with a fine suture of black silk and wrapped up in a moist gauze compress. The endothoracic fascia, which covers the pleura and constitutes a definite fibrous structure with strands of smooth muscle, is now carefully incised and dissected away from the pleura throughout the length of the incision. Now the pleura is entirely free and peels away very easily from the spinal column. Should it tear at this stage, it is immediately repaired with fine catgut under positive pressure. I encountered this complication only once, during the first operation, with no harmful consequences. After the pleura has been stripped away from the proximal stumps of the ribs, which by the way are the most frequent sources of a pleural injury, it is wise to remove the remaining proximal stump and some of the transverse process with a double action bone-biting forceps. The pleura is now gently stripped with the right index finger, until the thoracic sympathetic trunk appears, surrounded by more or less loose connective tissue and fat. It may strip away with the pleura, in which case it escapes detection under the retractor, but if the endothoracic fascia has been split, it will remain on the bodies of the vertebræ. Good lighting in the form of lighted retractors or a headlight and continuous suction of the accumulating blood should insure a dry, well-exposed field. The thoracic sympathetic trunk may be identified by the bulbous swelling of its ganglia. Dissecting the pleura farther forward, the major splanchnic nerve appears, showing multiple connections with the sympathetic chain. Quite at the bottom of the field, just above the diaphragm, originating from the lowest thoracic segments, the minor splanchnic nerve may be identified but a search for it is unnecessary, as the sympathetic trunk is widely excised and with it the origin of the lesser

splanchnic nerve. After flooding these structures with novocain, both thoracic chain and splanchnic nerve are excised, removing as long a segment as possible. In order to prevent regeneration of the major splanchnic nerve, which occurs very rapidly in the dog, the proximal stump of the nerve is implanted into the distal stump of the tenth intercostal nerve (Fig. 1, insert B). I am indebted for this idea of sidetracking the regeneration of the splanchnic nerve into a peripheral nerve to Dr. S. W. Ranson, Director of

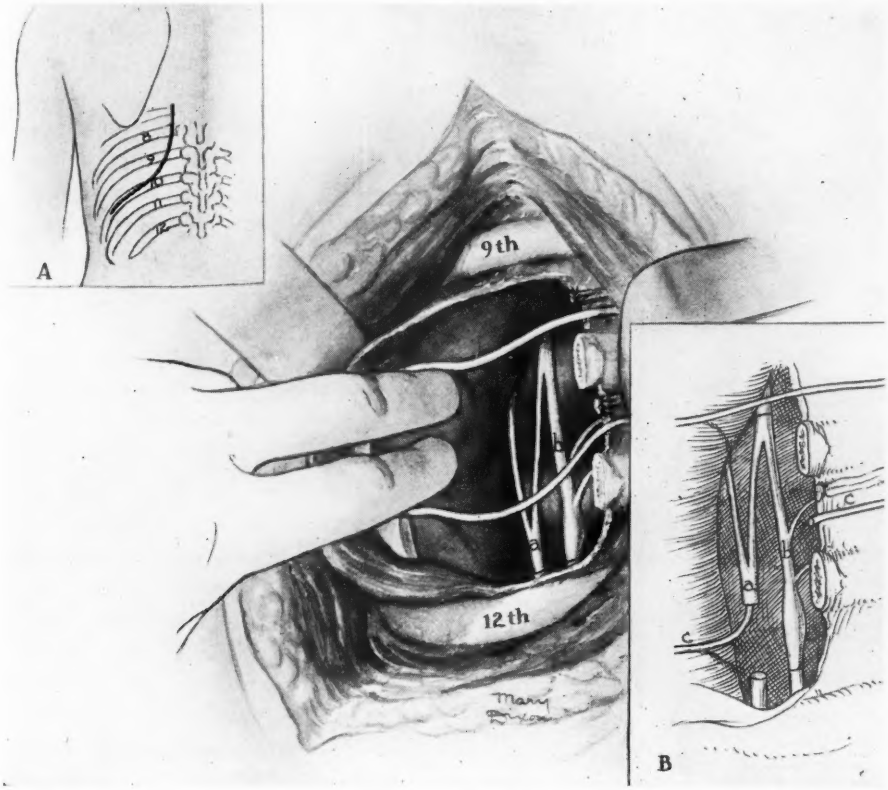

FIG. 1.—Insert A shows the line of incision, starting at the level of the scapular angle and swinging laterally at the level of the tenth rib. In the main drawing *a* is the major splanchnic nerve, *b* is the thoracic sympathetic trunk. The pleura has been reflected from the spinal column, the intercostal vessels have been ligated and only the intercostal nerves preserved. Insert B shows the method of anastomosing the proximal stump of the splanchnic nerve (a) to the distal stump of the tenth intercostal nerve (c).

the Institute of Neurology at Northwestern University Medical School. In the last two operations this procedure has been adopted, with no indication of any intercostal neuralgia or abnormal sympathetic reflex phenomena.

In regard to any possible vascular injury, care must be taken to avoid the intercostal veins entering the azygos and hemiazygos veins, respectively. These large collector veins are not in such close proximity to the splanchnic at this level, as they are below the diaphragm where their injury is much less readily avoided. After a complete hæmostasis, the pleura is allowed to fall back in its place, the muscles are carefully sutured with plain catgut

sutures and the skin closed, after meticulous adaptation of the skin edges with interrupted silk sutures. No drainage is left in the wound. The chest is adequately supported with wide adhesive tape.

Post-operative Management.—An adequate glucose and fluid intake, which is essential in any operation on diabetics, is carefully maintained. Five per cent dextrose solution is given in a subcutaneous drip, 1,000 cubic centimeters in about five hours, which can be started during the operation, and another 1,000 cubic centimetres in the afternoon. Two thousand cubic centimetres of 5 per cent dextrose solution will supply 100 Gm. of sugar. Another 1,000 cubic centimetres of Ringer's solution is given during the night, thus furnishing 3,000 cubic centimetres of fluids during twenty-four hours. While after laparotomies or retroperitoneal operations oral feeding may have to be delayed for two to three days, the thoracic approach permits an early administration of fluids by mouth. Thus, in all six instances the 100 Gm. of dextrose could be furnished by mouth the day following operation. The liquid diet consists of orange juice, milk, but better than that, sweetened tea. Orange juice in larger amounts frequently increases post-operative distention and is more irritating to the bowel than sweetened tea. Should the entire 100 Gm. be not consumed by mouth, another quart of 5 per cent, dextrose under the skin easily supplies half of it.

FIG. 2.—Photograph of patient's back a few weeks after the two-stage operation. This boy lifts heavy weights and works all day on a farm. The function of the back is unimpaired.

The patient must be considered a total diabetic right after the operation and the dextrose given must be completely covered by insulin. As mentioned above, the urine is examined every four hours for sugar and acetone bodies. A red reduction calls for twenty units, an orange reduction calls for fifteen units, a yellow reduction for ten, a green reduction for five, and no reduction for omission of insulin. All these patients require at least forty-five units of insulin right after the operation and probably more, but the insulin requirement suddenly drops after a few days when the post-operative reaction subsides. The urinary control protects from insulin reactions, but it is wise to have an ampule of 50 per cent dextrose at the bedside for any untoward event.

The patient is made to sit up the evening of the operation and breathing exercises are started the next day. Enough morphine is given to make deep

breathing possible. A mild enema of an ounce of glycerin and water each is given on the morning of the third day. After from ten to twelve days the patient is usually fit for an operation on the other side. The average stay in the hospital including ten days of pre-operative preparation was one month.

Results.—The surgical convalescence of three patients who underwent six operations was uneventful. The first patient developed a unilateral pneumothorax, which disappeared in a few days. The last patient had a subcutaneous exudate from a continuous chromic catgut suture, which promptly disappeared when the catgut suture was removed. There was no limitation of motion in the back; the third patient (Fig. 2) did heavy labor on a farm six months after the operation.

Preliminary reports[11, 12] reporting the effect of splanchnic section on the diabetic state of the patient have already been made. Fenn and I will analyze the end-results of this operation, its effect on alimentary hyperglycæmia and insulin sensitivity. In this paper, which is primarily concerned with the technical aspects of this procedure, I merely wish to summarize our experience with the three patients, to date.

CASE I, a nineteen-year-old colored girl who was resistant to insulin and whose galactose-hyperglycemia was readily diminished by ergot. In this case the insulin requirement dropped from forty to twenty units after the left side had been operated on. No further reduction was obtained after the second operation. She later became pregnant, broke her diet, aborted and lost some of her tolerance. From later surgical experience it may be stated with some assurance that the transection on the right side was incomplete and that adequate measures to prevent regeneration of the stump were not taken. She can be classed as a partial failure, mainly due to incomplete operation, aggravated by the complicating pregnancy and abortion.

CASE II, a sixteen-year-old white boy with a severe type of juvenile diabetes, showed no gain in tolerance, no change in the reaction to insulin and to galactose. This patient is a type of diabetic who showed no evidence of increased sympathetic impulses to the liver and could therefore not gain anything by the sympathetic denervation of liver and adrenals. It is only after this experience that the great importance of differentiating and excluding this type of diabetic from any surgical consideration was recognized. This case is classed as a complete failure, owing to the improper selection of the patient.*

CASE III, a twenty-four-year-old diabetic lad, had an arrested pulmonary tuberculosis, and recurrent hyperthyroidism which was checked by a subtotal thyroidectomy. Thyroidectomy reduced the insulin requirement from seventy to fifty-five units. Following bilateral splanchnic section, the insulin requirement dropped to ten units. Because the patient had gone back to work, the post-operative diet had to be increased with 700 calories, but no further increase in insulin was necessary. A reduction to five units was accomplished by small daily doses of ergot. This patient is very sensitive to insulin but needs a small amount, without which he spills large amounts of sugar. This case is undoubtedly the most successful to date, but the fact that he had X-ray evidence of pulmonary tuberculosis and a marked hyperthyroidism somewhat clouds the picture and interferes with the result. A final report will be made in detail at a later date.†

* This patient died during the first week of November, 1934, in a diabetic coma.

† After a strenuous summer on a farm, this patient showed a reactivation of his pulmonary tuberculosis. A large cavity appeared in one apex and the sputum became positive for Koch-bacillus. At the time of this note (Nov. 16, 1934) he is still maintaining the gain in tolerance.

Summarizing the results, the two important causes of failure, namely, inadequate technic and improper selection of the patient, have become obvious and may pave the way for more successful cases. These operations are admittedly experiments undertaken to remedy perverted physiologic-mechanisms. To evaluate the results, the first two cases must be excluded as faulty experiments.

Comment.—Of the many theoretical and practical considerations that arise from the proposal of sectioning splanchnic nerves in juvenile diabetes, the following questions are most pertinent:

(1) What is the effect of splanchnic-nerve section? In our animal experiments, to be published,[3] it was found that this operation raises the sugar tolerance of the normal dog and markedly increases insulin sensitivity. The dogs store more glycogen in the liver, and this glycogen is more firmly fixed, because adrenalin does not readily mobilize it.[13] It was also found that splanchnic section was equally effective in raising sugar tolerance as adrenal denervation.

(2) What is the advantage of splanchnic-nerve section over adrenal denervation? This question must be asked, as Crile has advocated adrenal denervation as a "dekineticizing" operation and has included diabetes among his indications.[14] My reason for selecting splanchnic section instead of adrenal denervation is as follows: The splanchnic nerves control a far larger area than the suprarenal fibres; the abolition of central or reflectoric vasoconstrictor impulses to the extensive vascular supply of the islets may be of benefit. The deprivation of the liver of its sympathetic nerve supply definitely increases its storing and retaining capacity for glycogen.[13] In regard to the adrenal glands, their denervation is practically as complete by splanchnic section as by adrenal denervation, although undoubtedly some fibres from the celiac plexus or lumbar sympathetic chain remain uncut. But regeneration after adrenal denervation ocurs rapidly and a section of *all* nerve fibres to the adrenals remains, to say the least, a questionable possibility. The prevention of regeneration, as described in our operative procedure, can hardly be accomplished except by a supradiaphragmatic, retropleural approach.

It remains to be seen whether such a major surgical procedure is justifiable in a disease, the etiology of which is unknown and the transmission of which as a Mendelian recessive is being made more and more convincing.[15] It is felt, however, that some of the obstacles in successfully attacking juvenile diabetes by splanchnic section have been cleared away by our initial experiences. Further observations on a larger material are being stimulated by the third case, in which a reduction from fifty-five to five units of insulin was accomplished, as a sudden but persistent result of the operation. No known surgical or medical procedure, including the total thyroidectomy as reported by Wilder and Pemberton[16] has been capable of producing such a marked fall in insulin requirement.

Other possible effects of splanchnic-nerve section on gastro-intestinal motility, secretion and blood-pressure have been studied. There is no lasting

effect in influencing any of these normal mechanisms. This does not mean, however, that if abnormal mechanisms were present, they could not be influenced.[9]

SUMMARY

A supradiaphragmatic retropleural approach to the splanchnic nerves has been described. The operation has been performed so far in three juvenile diabetics. Because of improper case selection in one case and partial technical fault in the second, only the third case is regarded as a thorough test of the value of the operation. In this patient a decrease of fifty units of insulin a day was accomplished. A final evaluation of results with data on the diabetic state of the operated patients will be made.

REFERENCES

[1] de Takats, Géza, Fenn, G. K., and Trump, R. A.: Splanchnic Nerve Section in Juvenile Diabetes. I. Selection of Cases for Operation. Ann. Int. Med., vol. 7, pp. 1201–1216, 1934.

[2] de Takats, Géza, and Cuthbert, F. P.: Effect of Coeliac Ganglionectomy on the Sugar Tolerance of Dogs. Am. Jour. Physiol., vol. 52, pp. 614–619, 1932.

[3] de Takats, Géza, and Cuthbert, F. P.: The Effect of Adrenal Denervation and Splanchnic Nerve Section on the Sugar Tolerance of Dogs. Arch. Surg. (In press.)

[4] Root, Howard F.: The Association of Diabetes and Tuberculosis. New Eng. Jour. Med., vol. 210, pp. 1–12, 78–91, 127–146, 192–206, 1934.

[5] Jean, G.: Essai sur la Chirurgie des crises gastriques du tabes. Lyon Chir., vol. 18, pp. 339–350, 1921.

[6] Pieri, G.: La cura chirurgica delle nevrosi gastriche. Belluno. Tipografia Editrice "La Cartolibraria," 1930.

[7] Rossi, F.: La resezione del tronco simpatico toracico e dei nervi splanchnici nello spatium inframediastinale posterius. Arch. ital. di. Chir., vol. 21, pp. 729–740, 1928.

[8] Pereira, A. de S.: Nervi splanchnici; contribiucao para o estudo de anatomia e chirurgia dos nervos esplancnicos. Tipografia Porto Medico, Porto, 1929.

[9] Craig, W. McK.: Surgical Approach to and Resection of the Splanchnic Nerves for Relief of Hypertension and Abdominal Pain. Western Jour. Surg., Obstet., and Gynec., vol. 42, pp. 146–152, 1934.

[10] Härtel, F. F.: Die Chirurgie des Retroperitonealraumes und des dorsalen Bauchfell. Erg. der Chir. und Orth., vol. 26, pp. 60–153, 1932.

[11] de Takats, Géza, and Fenn, G. K.: Bilateral Splanchnic Nerve Section in a Juvenile Diabetic. Ann. Int. Med., vol. 7, pp. 422–430, 1933.

[12] de Takats, Géza, and Fenn, G. K.: The Effect of Surgical Procedures on the Sugar Tolerance of Diabetic Patients. Presentation of Four Cases. Med. Clin. N. Am., vol. 17, pp. 1508–1519, 1934.

[13] de Takats, Géza, Cuthbert, F. P., and Vandolavy: The Effect of Splanchnic Nerve Section on Glycogen and Fat Storage in the Liver. (Unpublished.)

[14] Crile, George W.: Denervation of Adrenal Glands for Neuro-circulatory Asthenia; Technic and Clinical Results. Surg., Gynec., and Obstet., vol. 54, pp. 294–298, 1932.

[15] Pincus, G., and White, Priscilla: On the Inheritance of Diabetes Mellitus. Am. Jour. Med. Sci., vol. 186, p. 1, 1933.

[16] Wilder, R. M., Foster, R. F., Pemberton, J. de J.: Total Thyroidectomy in Diabetes Mellitus. Proc. Staff Meet. Mayo Clinic., vol. 8, pp. 720–729, 1933.

INFECTIVE GRANULOMA OF STOMACH

PSEUDOCANCER

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SURGEONS and pathologists of experience have encountered a condition of the gastro-intestinal tract that usually is erroneously diagnosed as neoplasm, most frequently cancer, which has proven inflammatory in nature on operation or postmortem examination. Notwithstanding the clinical importance of this condition, it has not been sufficiently stressed in the literature, and knowledge of it by the individual man is gained through disappointing experience.

Mock,[1] in one of the most complete reviews of the subject, named this lesion "infective granuloma," discussing at length the reasons for this name. From the clinical standpoint, however, it would attract greater attention if called by the name Le Dentu applied to it in 1909—"pseudocancer."[2] This name is especially appropriate in considering the lesion in its reference to the stomach. Whatever the etiology of these lesions may be, one fact is well established: they are not specific granulomata.

These inflammatory masses are met with not only in the gastro-intestinal tract, but, perhaps even more often, in the mesoblastic organs. Such a lesion occurring in bone has, on several occasions, been diagnosed as malignant and later reported as a cure from surgery. However, it is only when the lesion is situated in the stomach that the preoperative diagnosis is invariably wrong and only microscopic study reveals the true nature of the condition.

Because of their intrinsic benignity, these lesions are far advanced before surgical assistance is engaged; and because the prognosis, based upon the clinical examination and the roentgen ray, appears so grave the ultimate discovery that the lesion is benign is dramatic.

Two cases coming under my observation demonstrated to my satisfaction a few important clinical and pathologic points that deserve attention. In both cases, the preoperative diagnosis was carcinoma of the stomach, and surgery was advised merely as a palliation. Even at the time of the operation, I failed to distinguish the condition from a carcinoma, although I was struck by the extensive matting together of the stomach with the adjoining omentum and intestinal loops. The regional lymph nodes were enlarged and simulated carcinomatous involvement. At first, the histologic picture was baffling, but after repeated study the true inflammatory nature of the lesion was seen.

CASE REPORTS

CASE I.—A man, 54 years old, an American, a carpenter by trade, was complaining of postprandial pain for a number of years; when the pain would let up he felt quite

comfortable and had no distress whatsoever. Gradually the pain became a constant symptom. Two months before the admission to the hospital, he commenced vomiting undigested food and three weeks ago he could not retain water. He lost 52 pounds during the last six months, present weight 104 pounds. He was very pale and thin; his hemoglobin was 32 (Dare). A test meal revealed a total acidity of 18, free hydrochloric of 6, combined of 14 and blood. Roentgen rays showed an enormous filling defect (Fig. 1). The diagnosis of carcinoma of the stomach suggested itself, and, following a proper preparation of the patient, a wide resection of the stomach was done after Billroth II method, with a Pólya modification. Eighteen cm. of the stomach had to be removed so as to reach a safe margin beyond the lesion. The stomach was tightly adherent to the surrounding structures and the operation proved to be quite formidable. There was no vomiting following the operation. On the sixth postoperative day he showed evidence of peritonitis and he died two days later. Although no postmortem examination was done I feel that a leak from the duodenal stump was responsible for the peritonitis.

FIG. 1 (Case I).—Roentgen ray of stomach taken ten minutes after a barium meal. Showing the filling defect usually considered typical of carcinoma.

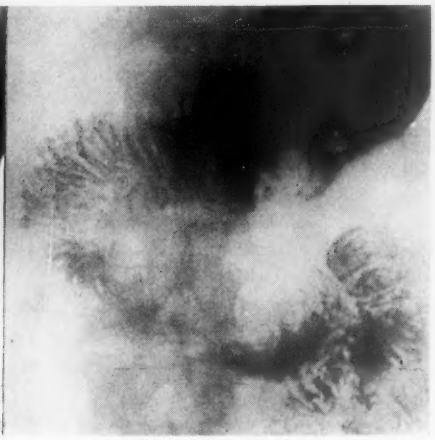

FIG. 2 (Case II).—Roentgen ray of stomach taken ten minutes after barium meal. Note the ragged-edged filling defect in the greater curvature near the pylorus.

CASE II.—A man, 43 years old, a Greek packing house employee, gave a history of upper abdominal distress related to meals for the last eight years. At first, the distress would come on in spells. Lately these became more frequent, and finally for two months before admission to the hospital he vomited undigested food repeatedly, and for the last week he even vomited water. A test meal disclosed a complete absence of free hydrochloric acid with a total acidity of 14, combined of 12, with a faint trace of lactic acid and two plus occult blood. Roentgen rays showed a definite filling defect (Fig. 2). The clinical diagnosis was carcinoma of the stomach, and a resection of the stomach was done May, 1931, after the Billroth II method. Because of dense adhesions of the stomach to the omentum, the duodenum and the pancreas, resection was tedious and difficult. During the first three months after operation he gained 28 pounds, resuming his usual occupation. The removed portion of the stomach measured 15 cm. in length; the resected part showed almost complete obstruction so that even a pencil could not be passed through the lumen.

The mucosa in the removed specimens of both cases appeared to be eroded in places. The specimens were extremely hard and leathery. The cut surface was white, glistening, with numerous yellowish spots; in places the cut edge felt cartilaginous. The lesion was not sharply circumscribed anywhere,

and faded out gradually into the normal stomach wall. Edema of the adjoining normal portion of the stomach made it difficult to be exact about the margin of the lesion. A close study of the advancing edge of the lesion sug-

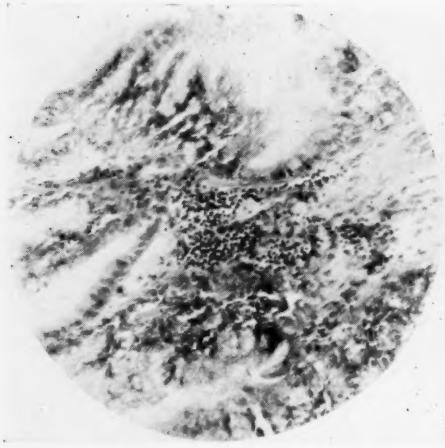

FIG. 3.—Section from tumor in Case II. Showing the early stage of involvement of the stomach. Note the round cell focal infiltration of the submucosa.

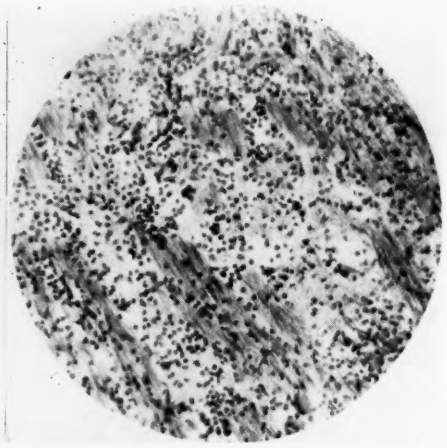

FIG. 4.—Section from same tumor as Fig 3. Further stage of involvement of the wall of the stomach. The round cell infiltration is diffuse and organization has begun.

gests that a break in the mucosa precedes the inflammatory changes in the wall of the stomach.

Histologically, one may distinguish several stages in the development of

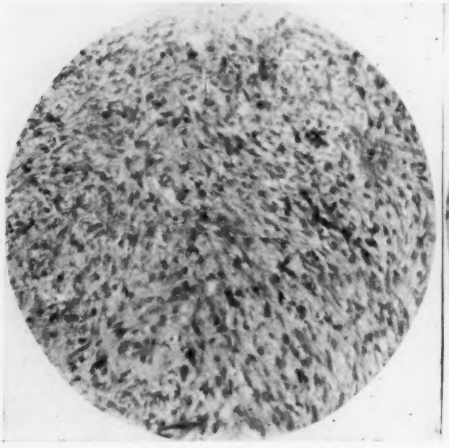

FIG. 5.—Section from same case as Fig. 3. The final stage of development of the tumor mass. Note the advanced organization of the resulting dense fibrous tissue.

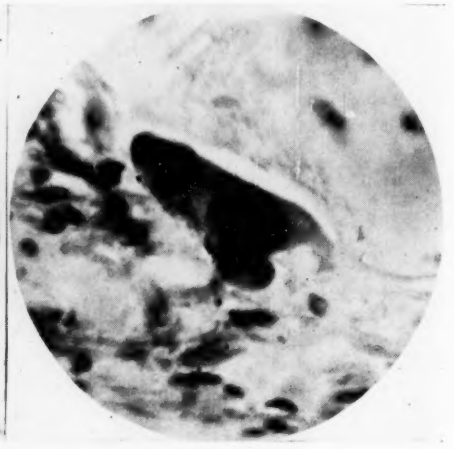

FIG. 6.—Section from same case as Fig. 3. Showing a large foreign body giant cell, as seen throughout the mature portion of the tumor mass.

the lesion. In the first stage (Fig. 3), we see an abundant, small cellular infiltration of the submucosa layer, which later leads to a diffuse infiltration of all the layers of the wall of the stomach (Fig. 4). An organization of this inflammatory exudate leads to the formation of a fibroblastic, dense, scar

tissue, that is responsible for the shrinkage of the wall of the stomach and for the narrowing of its lumen (Fig. 5). Dispersed among the numerous fibroblasts one sees foreign body giant cells (Fig. 6). When the inflammatory process reaches the serosa it causes a localized peritonitis that is responsible for the adhesion of the involved stomach to the adjoining organs. This peritoneal reaction is responsible for the postprandial pain.

Comment.—The diagnosis of gastric lesions by means of the barium meal and the roentgen ray is generally considered to be most reliable and trustworthy. My own embarrassment in the two cases presented here has taught me that one does well to be critical in the evaluation of the roentgen ray findings. This is said without any disrespect of roentgenology of the stomach, since even after the lesions are removed and studied in the pathologic laboratory, it takes a great deal of careful examination before the true diagnosis can be made.

Of course, it would be too much to expect that the clinician make the diagnosis of pseudocancer in these cases from the clinical examination alone. Looking back at these two cases, there are certain points which should have warned me against making the diagnosis of malignancy. The long duration of the illness with periods of complete freedom from symptoms, the absence of true cachexia in either of these patients, although a marked secondary anemia was present, and finally the postprandial pains which formed a prominent symptom in both of these cases, and which are seen in carcinoma of the stomach only after the tumor has reached the serosa, should have been given more consideration in the diagnosis than they actually received. And yet, when we are dealing with a middle aged man that has lost considerable weight because of repeated vomiting and who presents a palpable mass in the epigastrium, the suspicion of carcinoma of the stomach is great indeed. If in such a patient the roentgen ray shows a ragged edged filling defect and a delay in emptying time, one is naturally apt to accept these findings as evidence of malignancy. Despite this seemingly unimpeachable evidence of malignancy, the lesions here proved to be benign.

REFERENCES

[1] Mock, H. E.: Infective Granuloma. Surg., Gyn., and Obst., vol. 52, p. 672, 1931.

[2] Le Dentu: Faux cancers et tumeurs inflammatoires du ventre. Bull. de l'Acad. de méd., vol. 62, p. 289, Paris, 1909.

FIBROSARCOMA OF THE STOMACH*

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SARCOMAS of the stomach are uncommon. According to D'Aunoy, Rigney and Zoeller,[3] they comprise 1 per cent of all malignant growths in the stomach and 0.25 per cent of all sarcomas. Of the 135 cases of gastric sarcoma studied in detail by these authors, in only seven cases (5.2 per cent) were the growths fibrosarcomas. Gossage and Hicks,[6] in 1913, were among the first to record the finding of this type of sarcoma at postmortem examination. Holmes,[7] in 1919, described the successful resection of a similar tumor from the greater curvature. His patient, a man, was living and well six years later. Pemberton,[9] in 1929, added another case of successful resection of a pedunculated fibrosarcoma weighing 650 Gm. and measuring 20 cm. in its greatest diameter. D'Aunoy, Rigney and Zoeller were able to collect from the literature 335 cases of gastric sarcoma. Bell[2] stated that gastric fibrosarcomas seldom metastasize. Ewing[5] was of the opinion that infection and congenital anomalies of the wall of the stomach might play important rôles in the causation of sarcoma.

In 1930, Balfour and McCann[1] stated that there were five fibrosarcomas in a group of 45 carefully studied sarcomas of the stomach which were collected at the Mayo Clinic between the years of 1908 to 1929. Resection of the tumor, with a Pólya type of anastomosis to restore gastro-intestinal continuity, gave the highest percentage of permanent cures (29.5 per cent). The symptoms commonly complained of were: dyspepsia, epigastric pain, fulness after meals, belching, and loss of strength. The usual physical findings were: epigastric tumor, an average loss in weight of 23 pounds (10.4 Kg.), occasional vomiting, melena, and moderate emaciation. Thirty-eight of Balfour and McCann's patients were treated by resection, and only 12 (31.5 per cent) were living at the time of their report. At the clinic, from 1908 to November 1, 1934, 4,733 carcinomas of the stomach have been treated surgically; in the same period 72 sarcomas of the stomach have been resected, of which seven have been fibrosarcomas. This is an incidence of approximately one gastric fibrosarcoma to ten gastric sarcomas (9.73 per cent).

Ransohoff and Dickson[10] reported a case in which a gastric fibrosarcoma was successfully resected. They stated that these tumors are usually of a low grade of malignancy and commonly arise from the subserous layer of connective tissue in the stomach. They grow outward, attain great size, and are often pedunculated; rarely do they metastasize. At first glance they

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may appear to be inoperable because of their size and the adherence to them of the greater omentum and adjacent viscera. Such tumors usually arise from the greater curvature or from the posterior wall of the stomach in its middle third. Extensive resections are feasible with this type of sarcoma because of its sharp line of demarcation from the normal gastric wall. Deaudinsky[4] mentioned a gastric fibrosarcoma that weighed 6,000 Gm. In one of Cabot's case reports there was recently recorded an instance of a small fibrosarcoma of the stomach of apparent neurogenic origin that was successfully treated surgically.

We wish to report a case in which a large fibrosarcoma of the stomach required very extensive resection in order to effect a cure:

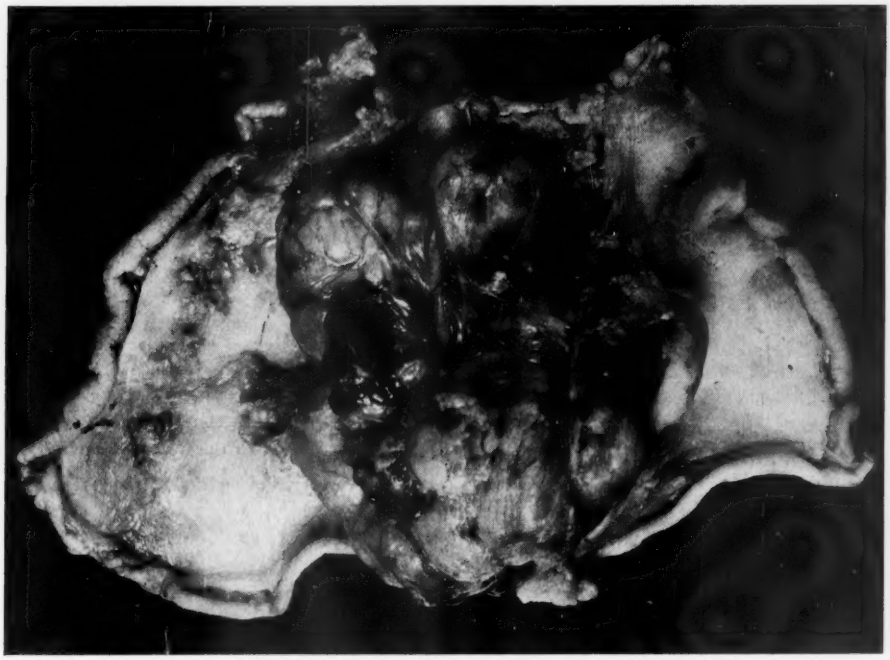

FIG. 1.—Gross specimen of distal two-thirds of stomach, showing a pedunculated fibromyxosarcoma, which measured 11 by 11 by 10 cm. and which arose from the lesser curvature.

CASE REPORT

A farmer, aged 65 years, registered at the clinic October 25, 1934. His father had died at the age of 61 and his mother at 81 from what was said to have been cancer of the stomach. His past history was essentially negative. There had been no previous operations. His chief complaint was the presence of an enlarging mass in the epigastrium of one year's duration, and of progressive weakness. In the past 20 years he had had, after meals, occasional epigastric pain of about 30 minutes' duration. There had been no nocturnal pain, melena, nausea, vomiting, or hematemesis. One year prior to his admission to the clinic he had noted the appearance of a small, non-tender mass in the left epigastrium which had steadily increased in size. His strength had steadily diminished. Physical examination revealed a loss of 13 pounds (5.9 Kg.), which had occurred in the past two months; a moderate degree of pallor; a palpable mass in the left epigastrium, which measured 2.5 by 4 cm. and was freely movable, smooth, firm, and non-tender, and

enlarged, tender lymph nodes in the left axilla. The laboratory findings revealed the following: The urine was negative. Hemoglobin was 10 Gm. per 100 cc. of blood. Erythrocytes numbered 3,390,000 and leukocytes 6,000 per cmm. of blood. The flocculation test of the blood for syphilis gave negative results. Blood smears were negative. Roentgenograms of the stomach gave evidence of a perforated, ulcerating lesion on the lesser curvature in the middle third, probably malignant.

Operation.—October 27, 1934. First, two nodes were removed from the left axilla, these were reported inflammatory. Through an upper right rectus incision what was thought to be an ulcerating carcinoma of the lesser curvature was encountered; this mass was exogastric in character, filled the lesser peritoneal cavity, and apparently was inoperable. Further investigation showed that the tumor could be mobilized and that it did not involve neighboring viscera. Consequently, the first portion of the duodenum was divided, the stump inverted, and the distal three-fourths of the stomach resected, going well cephalad to the growth. A posterior Pólya type of anastomosis restored gastro-intestinal continuity. The pathologist reported that the lesion measured 11 by 11 by 10 cm. (Fig. 1), and that it was a pedunculated mass of mesentery and wall of the stomach; the tumor extended inward only to beneath the muscularis mucosa. Microscopic study of the tumor revealed it to be an hemorrhagic fibromyxosarcoma of Grade 2 or 3; parts of the tumor had the appearance of a neurofibroma.

The patient's postoperative course was uneventful, until the fourteenth day when bilateral bronchopneumonia developed. Oxygen therapy was used for the next five days. On the twenty-fourth day the temperature again became normal and the patient was dismissed from the hospital on the thirty-fourth day following operation. Postoperative roentgenograms of the stomach showed a free anastomosis and no signs of recurrence.

REFERENCES

[1] Balfour, D. C., and McCann, J. C.: Sarcoma of the Stomach. Surg., Gyn., and Obst., vol. 50, pp. 948–953, June, 1930.

[2] Bell, E. T.: A Text-book of Pathology. P. 468, Philadelphia, Lea & Febiger, 1930.

[3] D'Aunoy, Rigney, and Zoeller, Adelaide: Sarcoma of the Stomach. Report of Four Cases and Review of the Literature. Am. Jour. Surg., vol. 9 (n. s.), pp. 444–464. September, 1930.

[4] Deaudinsky: Quoted by Ransohoff and Dickson.

[5] Ewing, James: Neoplastic diseases. Ed. ii, pp. 259–260, Philadelphia, W. B. Saunders Company, 1922.

[6] Gossage and Hicks: Quoted by D'Aunoy and Zoeller.

[7] Holmes, T. W.: Quoted by D'Aunoy and Zoeller.

[8] Lyons, Champ: An Unusual Gastric Lesion. Presentation of Case. New Eng. Jour. Med., vol. 209, pp. 557–558, September 14, 1933.

[9] Pemberton, J. deJ.: Sarcoma of the Stomach. Proc. Staff Meet. Mayo Clin., vol. 4, pp. 17–19, January 16, 1929.

[10] Ransohoff, J. L., and Dickson, T. R.: Sarcoma of the Stomach. ANNALS OF SURGERY, vol. 97, pp. 68–73, January, 1933.

ACUTE AXIAL TORSION OF THE UTERUS

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THE uterus in its normal state has little motility and is firmly held in place by the broad ligaments and the uterosacral ligaments. These widely distributed supports resist any tendency to torsion. But a large heavy fibroid of the subperitoneal type attached near the fundus of the uterus and well above the pelvic brim may rotate and exert traction on the uterus. It has inertia and a wide field of movement, and the more spherical its shape, the more easily it can rotate.

In 1909, Piquand and Lemeland[1] collected and reported 37 cases. Vautrin[2] added two the following year. By 1926, Hitzanidés[3, 10] had brought the total number of cases to 86. In 1932, Pavlos,[4] of Alexandria, added 15, bringing the total to 101. Thirty-two additional cases have been excluded because the torsion of the uterus was secondary to torsion of a fibroma with a pedicle and not due to the weight of the fibroma itself. With sessile fibromata the torsion of the uterus occurs at the same time as that of the fibroma.

These cases are of two types, acute and chronic. In the chronic cases there is a history of a long period of lower abdominal distress. In the acute cases there is sudden sharp pain which increases in intensity. In both types there is a round midline swelling having its origin in the pelvis and extending toward the level of the umbilicus. The point of torsion of the uterus is fixed, occurring as a rule at the level of the uterine isthmus. In three cases only the point of torsion was higher at the level of the insertion of the fallopian tubes.[5] The elongation of the uterine isthmus may be so pronounced as to reduce the region just above the cervico-corporeal junction to a cord and cause venous obliteration and edematous infiltration. Persistent torsion has resulted in distention of the uterus by blood or pus, and widespread hemorrhagic infiltration in pelvic and subperitoneal tissues. Engorgement may spread to tubes and ovaries with the formation of peritoneal adhesions. With further rotation the arteries may become occluded causing necrosis of tissue.

Diagnosis.—The condition of axial torsion of the uterus is rarely diagnosed clinically, the abdominal tenderness and rigidity suggesting ovarian cyst with twisted pedicle. According to Gordon-Watson,[6] two objections to this diagnosis are the solid consistency of the tumor and its apparent continuity with the cervix. Failure to pass a uterine sound may be of some diagnostic aid. In women still able to bear children cessation of the catamenia with acute abdominal pain and the presence of a smooth, solid, abdominal tumor continuous with the cervix point to axial torsion of the

uterus. Other symptoms may be present. In a puzzling case reported by Walker,[7] there was diffuse pain down the front of both thighs, although none of the three upper lumbar nerves supplying the area affected enters the pelvis.

Etiology.—The etiology of axial torsion of the uterus is unknown. Causes given for ovarian cyst with twisted pedicle do not apply in these cases. Changes in volume of the bladder or rectum will not cause rotation. Vautrin[8] suggests that peristaltic movements of the sigmoid may be the cause. Changes due to pregnancy play an important rôle, but the phenomenon is more common in nulliparae. Courty[9] points out that in all the series only five women were under 40 years of age: in Schultz's cases the patients were 25 and 27 years of age, respectively; Freund's patient was 21; Loblein's, 25; and Wörtz's, 19. Rokitansky, Kocberle, and Lindig[11] favor Sellheim's theory that torsion of the uterus is concomitant with torsion of the body. In one case the woman was a reaper by occupation and the repeated spiral movement of reaping with the sickle was considered the cause of the torsion. Hitzanidés[10, 12] believes that the weight, volume, and point of implantation of the tumor and the effect of gravity are sufficient factors to cause the torsion. The body of the uterus with a large myoma of ovoid shape may by the weight and traction of the fibroid be revolved on the isthmus and cervix.

Treatment.—Patients seek relief when the torsion causes severe abdominal pain. The extent of torsion varies between 200 and 360°, although Michalitz, Wertheim, and Homans[13] report a uterus twisted one and one-half times upon its isthmus. The treatment in women past the child-bearing period or in cases where adhesions from an old pelvic inflammatory process are present is total or subtotal hysterectomy, preferably the latter, because it is simple, rapid, less hemorrhagic and more aseptic. Cases in which complications of salpingitis, oöphoritis, or peritonitis arise present a problem. Some surgeons have successfully postponed operation until the patient had recovered from the shock of the acute torsion. Courty,[14] however, states that the best way to alleviate pain is to correct the torsion immediately. In cases in which the women may still bear children, enucleation of the myoma and detorsion of the uterus are indicated.

Case Report (Case No. 30921).—L. B., aged 32, female, married, mill-operator, entered the Truesdale Hospital January 4, 1934, complaining of abdominal distress, gaseous distention, and eructations, which had persisted for two weeks. Two days prior to admission the pain in the lower abdomen became more severe, most intense in the midline and spreading to each lower quadrant. The attacks were of irregular onset and not related to the intake of food. The appetite remained unimpaired. There was no nausea and bowel movements were normal.

The menstrual history was normal. The last period, however, ended 35 days before admission. Two days before entry there was a scant show which became free-flowing on the day of admission. The patient had been married two years and had never been pregnant. The past and family history was negative.

Physical examination revealed a well-developed and well-nourished woman in mod-

erate abdominal distress. Temperature 99.8°, pulse 100 and respirations 20. The heart and lungs were normal. Blood pressure 120/70. A large, tender, slightly irregular mass could be felt in the right lower quadrant of the abdomen extending to the midline. Vaginal examination revealed a mass to the right of the uterus. The uterus was apparently of normal size.

The urine examination was negative. Erythrocytes, 4,530,000; leukocytes, 11,800; and hemoglobin, 90 per cent (Tallquist). The differential blood count and smear were normal. The non-protein nitrogen was 28.5 mg. and the blood sugar 111 mg. per 100 cc. The Kahn examination was negative.

A preliminary diagnosis of ovarian cyst with twisted pedicle was made. Ectopic pregnancy seemed less likely but was considered.

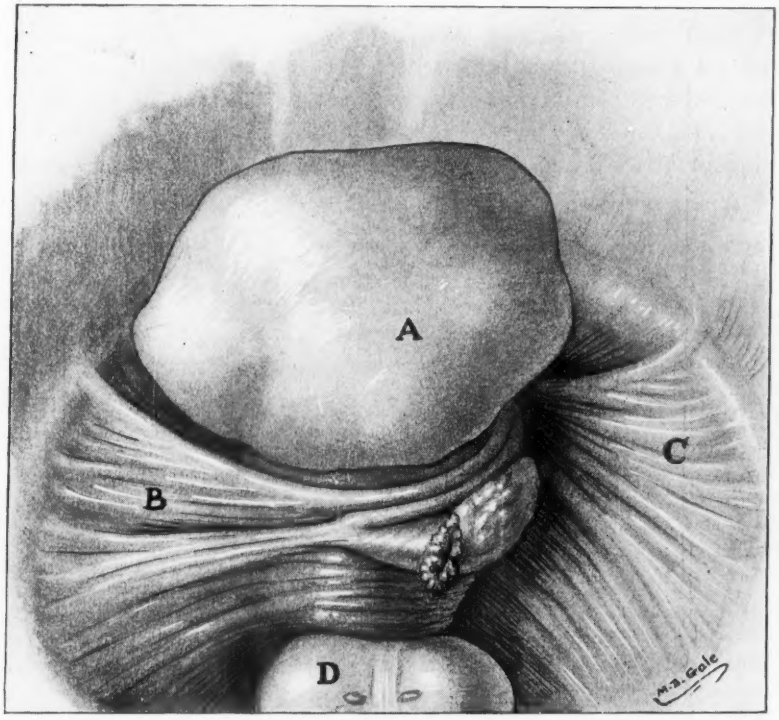

FIG. 1.—Posterior view of uterus. (A) Fibroid situated upon fundus of uterus. (B) Left broad ligament (wrapped around body of uterus). (C) Right broad ligament. (D) Rectum.

The following day under avertin anesthesia laparotomy was done through a lower midline incision. The peritoneal cavity contained a small amount of free blood. Exploration of the pelvis revealed an asymmetrical, nodular fibroid the size of a grapefruit situated upon the fundus of the uterus. The uterus itself was slightly larger and softer than normal and was twisted upon itself a complete turn of 360° at a point just above the internal os. The adnexa appeared normal. Except for its slightly congested appearance, the uterus seemed to show no serious interference in its blood supply. The torsion was easily corrected and with detorsion the color of the uterus rapidly changed to normal. Myomectomy was then done without opening the uterine cavity, and the musculature of the uterine fundus closed with two layers of catgut sutures. Incidental appendectomy was done and the abdomen closed in layers without drainage.

The patient made an excellent postoperative recovery. Convalescence, however, was somewhat prolonged by a right femoral phlebitis, which developed on the fourth postoperative day, and by a pulmonary infarction which occurred on the thirteenth postoperative day. These complications yielded satisfactorily to supportive treatment and the patient left the hospital recovered 30 days after admission.

Comment.—This case is typical of many reported in the literature. The uterus had undergone dextro-rotation through 360°, the torsion occurring in the region of the isthmus, which in this instance was not thinned out. In search for a site in the abdomen best suited to its shape, the myoma as it grew on the fundus rotated, pulling the uterus after it. The process of torsion was rapid after the fibroid had become large enough to exert traction on the uterus and cause symptoms of abdominal distress and pain. Torsion had not progressed to the extent of causing deep congestion or gangrenous changes in uterus or adnexa, although the uterus was somewhat congested. Myomectomy with detorsion sufficed to secure cessation of symptoms, and in view of the patient's youth more radical measures were not considered advisable.

REFERENCES

[1] Courty, L.: Presse méd., vol. 40, p. 790, May 18, 1932.
[2] *Ibid.*
[3] Hitzanidés, E.: Gynec. et Obstét., vol. 13, p. 103, February, 1926.
[4] Courty, L.: *Op. cit.*
[5] Cotte, G.: Lyon chir., vol. 28, p. 480, July–August, 1931.
[6] Gordon-Watson, C., and Shaw, W.: Jour. Obst. and Gynæc. British Empire, vol. 33. No. 3, pp. 424-425, 1926.
[7] Walker, A.: Jour. Obst. and Gynæc. British Empire, vol. 33, No. 3, p. 419, 1926.
[8] Gordon-Watson, C., and Shaw, W.: *Op. cit.*
[9] Courty, L.: *Op. cit.*
[10] Hitzanidés, E.: *Op. cit.*
[11] Lindig, O.: Zentralbl. f. Gynäk., vol. 49, p. 2876, December 19, 1925.
[12] Hitzanidés, E.: *Op. cit.*
[13] Walker, A.: *Op. cit.*
[14] Courty, L.: *Op. cit.*

TORSION OF AN INTRA-ABDOMINAL TESTICLE

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Torsion is a frequent complication of undescended testis. Undescended testis or cryptorchidism in its various forms is quite a common condition, occurring in 0.1 to 0.2 per cent of young adults. The maldescended testis, sometimes called the aberrant migration of the testis, while uncommon, is rarer than simple cryptorchidism. In view of the importance of this pathologic entity, a review of the embryologic changes in the development of the testis might be pertinent.

Embryonic Development of the Testis.—During the early stages of development the genital glands, testicles or ovaries, are situated far forward in the abdominal cavity. During the eighth week they lie opposite the lumbar vertebrae. During the succeeding months, up to the time of birth, they gradually move caudally to the positions they occupy in the adult. This migration is brought about, to some extent at least, by the influence of certain bands of tissue which are primarily like mesenteries. As the mesonephros develops and projects into the body cavity, it comes to be attached along the dorsal body wall, lateral to the dorsal mesentery, by a sheet of tissue which is called the mesonephric mesentery. Cranial to the mesonephros, this mesentery is continued as the diaphragmatic ligament of the mesonephros, which as the name indicates, is attached to the diaphragm; caudally it is continued to the inguinal region as the inguinal ligament of the mesonephros (Fig. 1). The genital gland lies on the medial side of the mesonephros and is attached to the latter by a sort of mesentery which becomes the mesovarium in the female or the mesorchium in the male. The cephalic portions of the ducts (Mullerian and mesonephros) lie close together in a ridge on the lateral surface of the mesonephros: as they pass caudally they extend around the ventral surface of the mesonephros and approach the medial line, and finally, in the pelvic region, the two ridges meet and fuse, forming the so-called genital cords. The genital cord thus contains the mesonephric and Mullerian ducts, the latter fusing to form a single tube (the anlage of the uterus and vagina). It also contains the umbilical arteries.

Such a condition is found in embryos of about eight weeks. From this time on the processes of development follow divergent lines in the two sexes, the differences becoming more marked from month to month. Certain structures persist and others disappear, according to the sex. The mesenteries and ligaments undergo metamorphoses and the genital glands migrate caudally.

Descent of the Testis.—As the mesonephros atrophies, its mesentery and the mesentery of the testicle are combined to form a single band of tissue, which, of course, is continuous with the inguinal ligament. The latter now

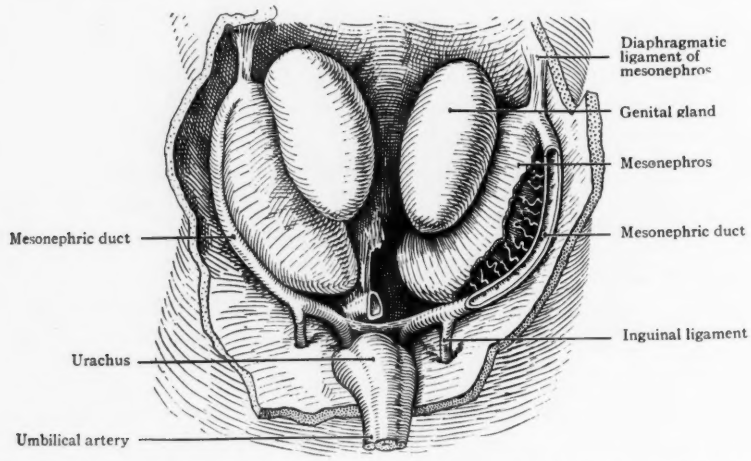

FIG. 1.—Urogenital organs in a human embryo of 17 Mm. (six weeks). (Kollman's Atlas.)

becomes the so-called gubernaculum testis (Hunteri), a strong band or cord composed of connective tissue and smooth muscle. Its cephalic end is attached to the epididymis, its caudal end pierces the body wall in the inguinal region

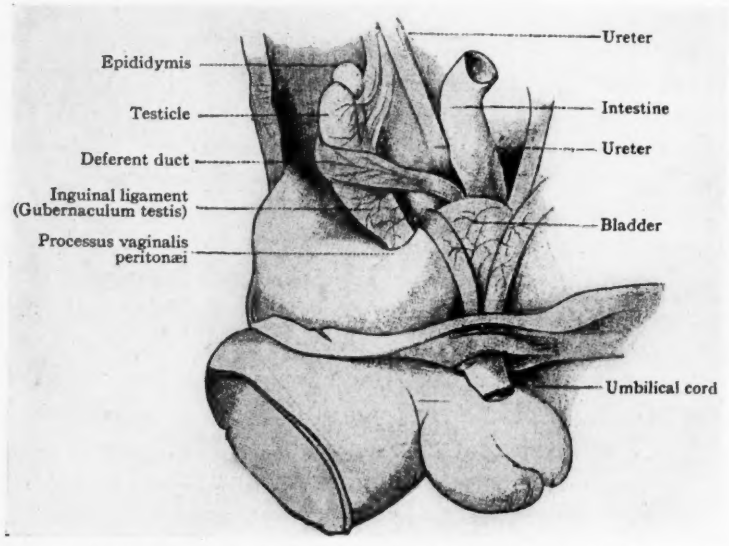

FIG. 2.—From a dissection of the pelvic region of a male human fetus of 21 cm. (Kollman's Atlas.)

and is attached to the corium of the skin (Fig. 2). It plays an important part in the descent of the testicle. The descent is brought about through the principle of unequal growth. As the body grows in length, the gubernaculum

grows much less rapidly and, since the caudal end of the latter is fixed, the natural result is the drawing downward of the testicle. This takes place gradually, and at the end of the third month the testicle lies in the false pelvis, at the end of the sixth month close to the body wall at the inguinal ring.

During the third month a second factor in the descent of the testicle appears. This is an evagination of the peritoneum at the point where the gubernaculum pierces the body wall. The evagination at first is a shallow depression, known as the processus vaginalis peritonei, but continues to burrow through the body wall and causes an elevation in the skin which is destined to become one side of the scrotum. The opening of the peritoneal sac into the body cavity is the inguinal ring. In its descent the testicle passes through the inguinal ring and comes to lie in the elevation in the skin or scrotum at about the ninth month. Whether its passage into the scrotum is the result of a traction by the gubernaculum is not certain. The inguinal ring then closes

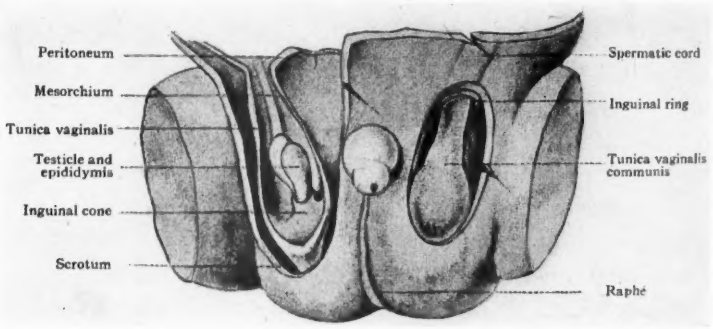

FIG. 3.—From a dissection of the scrotal region of a human fetus of 25 cm. (Kollman's Atlas.)

by apposition of its walls and the testicle lies in a closed sac which has been pinched off, so to speak, from the body cavity (Fig. 3).

Since the testicle is invested by peritoneum from the beginning of its development, it must be understood that in its passage into the scrotum it passes along under the peritoneum. Consequently when it reaches the scrotum it is surrounded by a double layer of peritoneum, the tunica vaginalis propia.

As a result of improper descent or failure of the testicle to take its proper course in the scrotum, certain anomalies occur, which can be classified anatomically as follows:

A. *Nondescended Testis.*—From the above description it is readily seen that the primary genital anlage of the testis is placed in close proximity to the primitive kidney. Before reaching its ultimate resting place in the bottom of the scrotum the testis must pass along the posterior abdominal parietes, through the inguinal canal and upper part of the scrotum. The testis may be arrested in any part of its course, and, in consequence, the following anomalies may be met with:

(1) The abdominal nondescended testis. The testis is arrested proximal to the internal inguinal ring.

(2) The inguinal nondescended testis. The testis is arrested in the inguinal canal.

(3) The pubic nondescended testis. The testis is arrested just beyond the external inguinal ring, *i.e.*, in front of the pubic bone.

(4) The upper scrotal nondescended testis. The testis is arrested in the upper part of the scrotum.

B. *Maldescended Testis.*—This variety differs from the preceding in the important fact that the testis is not arrested anywhere in its course. The organ is extruded through the external inguinal ring like a normal testis; at this point, however, it fails to take its proper course into the scrotum, and is deflected in other directions. When this occurs, we may have the following types:

(1) The inguino-superficial maldescended testis. The testis, after its extrusion from the external inguinal ring, is deflected upward and outward and lies upon the aponeurosis of the external oblique muscle, between it and the deep layer of the superficial fascia.

(2) The crural or cruro-scrotal maldescent of the testis. The testis lies in the upper part of Scarpa's triangle, or more frequently in the angle formed by the thigh and scrotum.

(3) The perineal maldescended testis. The testis, after its extrusion from the inguinal canal, migrates into the perineum.

(4) Transposition of the testis. In this exceedingly rare condition, the testis of one side migrates intraperitoneally, and is extruded through the opposite inguinal canal, into the opposite scrotal half. While this in effect is also a maldescent, it is not so in the strictest sense.

TORSION OF THE TESTICLE

Torsion of the testicle is a misnomer, and should really be called torsion of the spermatic cord, as this really gives a better description of the condition. There is an axial rotation or twist of the cord itself with a cutting off of the blood supply to the testicle and epididymis, resulting in local and general symptoms due to the inflammation and subsequent gangrene.

Incidence.—The number of cases of torsion of the testicle reported in the literature is really not a true index of the incidence of this condition. Prior to 1920 there were only 120 cases reported. Since then many others have been added, Campbell[3] alone reporting 15 cases from Bellevue Hospital in a period of six years. The incidence of torsion of an intra-abdominal testicle, however, is quite low. Ormond,[11] in 1927, collected five cases from the literature, adding his own as the sixth. Since then four more have been added, which with the author's case makes 11 known cases of this condition thus far reported in the literature.

CASES OF TORSION OF AN INTRA-ABDOMINAL TESTICLE

Case	Author	Year	Side Involved	Presence of Malignancy	Ectopic Testicles
1	Gerster	1897	Right	Yes	Bilateral
2	Stiles	1905	Right	Yes	Unilateral
3	Le Conte	1907	Right	Yes	Unilateral
4	Howard	1907	Right	No	Bilateral
5	Cupler	1915	Right	No	Unilateral
6	Ormond	1927	Right	No	Unilateral
7	Pearlman	1927	Left	Yes	Unilateral
8	Wallenstein	1927	Left	No	Bilateral
9	S. Power	1933	Left	No	Unilateral
10	E. C. Chitty	1933	?–	Yes	?–
11	A. J. Beller	1934	Left	No	Bilateral

An examination of these cases shows that the left side is almost as frequently involved as the right, although up to 1927, in the series reported by Ormond, all the cases were on the right side. Since then all the additional cases have been found on the left side. It may also be noted that of the 11 cases, four had bilateral undescended testicles and in one this was not reported. Much has been said about the development of malignancy in undescended testis; of the 11 cases in the literature five had a malignant tumor in the affected side.

Etiology.—Torsion is more prone to occur in patients with undescended testicles than in patients with normally descended testicles. In an analysis of 150 cases of torsion, Wallenstein[16] noted that 90, or 60 per cent, occurred in patients with either undescended or maldescended testicles. When one considers the incidence of ectopic testicle in relation to those normally descended, this figure becomes much higher.

There are four anatomic factors which play an important rôle in the causation of torsion of the testicle: (1) Abnormally loose scrotum; (2) voluminous tunica vaginalis; (3) unusually long gubernaculum or retained lengthened mesorchium; (4) abnormal attachment or location of the cord. From a consideration of the anatomy and the recorded cases, the last two factors appear to play the most important part in torsion of abdominal testis. Moschcowitz[9, 10] has pointed out that in the maldescended testicle, the cord structures are normal in every respect excepting location. Thus the vas deferens is of ample length and consequently cannot be given the primary rôle in maldescent of the testis.

The factor precipitating torsion in all of the cases presented has been a sudden strain usually occurring in the normal routine of the patient. The onset has always been sudden.

Symptoms.—In all of the cases reported the symptoms had continued more or less acutely up to time of operation. (In Stiles'[15] case, four acute attacks were noted before operation with periods of freedom from symptoms.) In none had a rectal mass been palpated and in only one instance (S. Power[13]) was rectal tenderness noted. In the case to be presented, it

FIG. 4.—Showing torsion of the left testicle with its pedicle emerging just above the internal inguinal ring and the relationship of the testicle to the rectum and bladder.

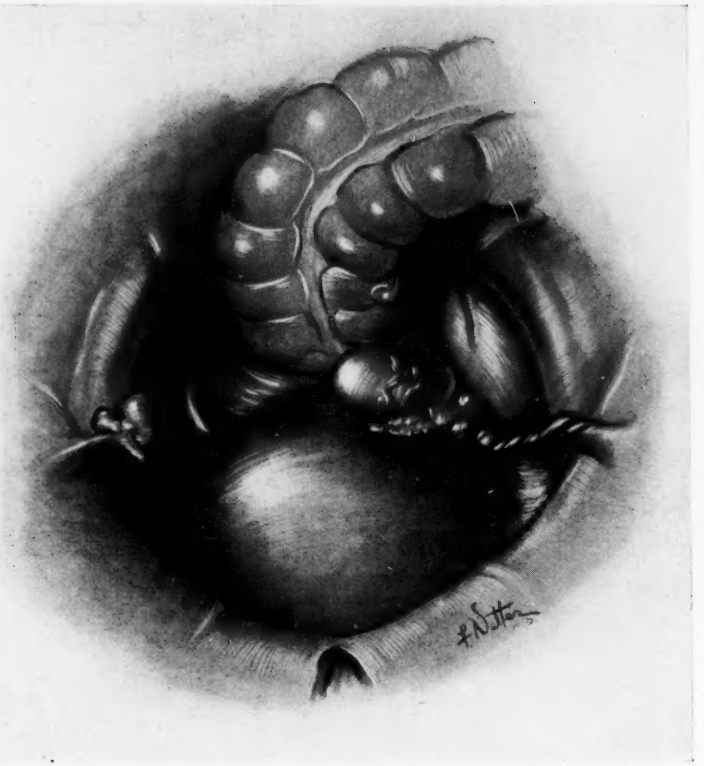

FIG. 5.—Showing bilateral intra-abdominal testicles, a small right one and a much enlarged gangrenous left one, due to the torsion of the cord.

will be seen that symptoms disappeared entirely within eight days after onset, and a rectal mass with tenderness was present.

The disappearance of pain following onset of gangrene with torsion was noted by Meredith Campbell[3] in patients with torsion of the testicle in sites other than abdominal. Wallenstein[16] in presenting the eighth example of the syndrome reviewed the cases as to symptomatology, mode of onset, *etc.*

CASE REPORT.—L. E., 28-year-old white male, entered Mt. Sinai Hospital with the complaint of pain in both lower quadrants, more marked on the left side. The pains were rather sharp and sticking in character, and seemed to radiate over the entire abdomen. They were relieved somewhat by lying down and aggravated by physical exertion, and after eating. There was no associated nausea or vomiting. Since the onset of his illness there had been no spontaneous bowel movements but daily enemata had returned brown fluid with little feces. There were no significant findings in his past history.

In the physical examination the findings of importance were moderate abdominal tenderness in both lower quadrants more marked on the left where voluntary rigidity was also present. The testicles were not in the scrotum or in the inguinal canals. Rectal examination revealed a small prostate just above which a small, soft, tender mass could be palpated on the left side. Its limits could not be definitely determined.

FIG. 6.—Specimen of left testicle, epididymis, and pedicle after removal.

The patient volunteered the information that his testicles had never descended. He has been married three years; sexual intercourse was satisfactory but sterility present. Secondary male sex characteristics were normal; beard and male hair distribution were present.

Temperature was 100.2°, returning to normal in a few days. The white blood count was 8,000 with a normal differential. Hemoglobin was 70 per cent. Sigmoidoscopy.—Instrument could be passed only 15 cm. at which point there was an obstruction due to a small tender mass the nature of which could not be determined. Roentgen ray reports.—Flat film of abdomen revealed no pelvic mass. Barium enema revealed no obstruction, constriction, or filling defect. Intravenous pyelogram taken to determine the presence of a possible ectopic pelvic kidney revealed normal kidneys, ureters and bladder. An Aschheim-Zondek test done to eliminate the possibility of teratoma was negative.

Ante-operative Course.—The symptoms gradually diminished and disappeared entirely within about five days with bed rest. The rectal mass was still moderately tender and had not changed in size. Foreign body perforation, metastatic tumor, and torsion of an intra-abdominal testicle were considered. From the history and physical signs of the case, the persistence of the rectal mass, and the absence of testicles in either the scrotum or inguinal canal, the author was led to suspect that the diagnosis of a torsion of an intra-abdominal testicle was a possibility. Exploratory laparotomy was performed 20 days after his admission.

Operative Findings.—The pelvis contained a small amount of old blood. Occupying the left side of the pelvis was a mass to which were adherent the bladder in front, the

sigmoid above and the rectum below (Fig. 4). After freeing the mass, it was found to be an intra-abdominal testicle suspended above the internal ring by a pedicle consisting of cord structures surrounded by peritoneum. This had been twisted about one and one-half times on itself and appeared bluish-black, swollen and gangrenous. A left epididymo-orchidectomy was performed. Examination of the right testicle revealed it to be lying freely in the peritoneal cavity attached by the cord structures above the internal ring on that side (Fig. 5). Postoperative course uneventful.

Pathologic Examination.—Doctor Otani reported the specimen to consist of a testicle, epididymis, and a portion of the vas. The specimen at the time of description has been fixed and reveals a torsion of the vas as though on a twisted pedicle. This is approximately 5 cm. above the upper pole of the epididymis. The epididymis is hemorrhagic and enlarged so that the width approaches about 2 cm. and its length 5 cm. The testicle also is distended as though infarction had taken place. It measures 5½ by 4 by 3½ cm. (Fig. 6).

SUMMARY.—(1) This is the eleventh case of torsion of an intra-abdominal testicle to be reported.

(2) It presents several unique features:

(*a*) The testicle had fallen into the pelvis and was palpable as a tender mass per rectum.

(*b*) The symptoms ceased within eight days of the onset.

(*c*) Operation was performed 23 days after onset of symptoms.

(3) This case adds to the list another left-sided torsion of an intra-abdominal testicle making the left side almost as frequent as the right in the cases reported to date.

(4) Five of the 11 cases which have been reported have shown the presence of malignancy.

REFERENCES

[1] Alyea, E. P.: Surg., Gyn. and Obst., vol. 49, pp. 600–616, 1929.
[2] Bailey, and Miller: Text Book of Embryology, pp. 421–426, 1909.
[3] Campbell, M. F.: Surg., Gyn. and Obst., vol. 44, pp. 311–316, 1927.
[4] Chitty, E. C.: Mayloyan Med. Jour., vol. 8, p. 203, 1933.
[5] Cupler: Surg., Gyn. and Obst., vol. 21, p. 250, 1915.
[6] Gerster: ANNALS OF SURGERY, vol. 27, p. 64, 1897.
[7] Howard: Brit. Med. Jour., vol. 2, p. 719, 1907.
[8] Le Conte: Internat. Clin., vol. 4, 17th series, 1907.
[9] Moschcowitz, A. V.: ANNALS OF SURGERY, vol. 8, p. 821, 1910.
[10] Moschcowitz, A. V.: Johnson's Operative Therapeutics, vol. 4, pp. 51–52.
[11] Ormond, J. K.: ANNALS OF SURGERY, vol. 85, pp. 280–283, 1927.
[12] Pearlman, S. J.: Jour. Urol., vol. 18, p. 637, 1927.
[13] Power, S.: Lancet, vol. 2, p. 865, 1933.
[14] Scudder, C. L.: ANNALS OF SURGERY, vol. 34, p. 234, 1901.
[15] Stiles: Tr. Med. Chir., vol. 25, p. 5, 1905.
[16] Wallenstein, S.: Jour. Urol., vol. 21, pp. 279–288, 1929.

RUPTURED PYO-URACHUS COMPLICATED BY URETHRAL STRICTURE

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THE name "pyo-urachus" was first introduced by Stevens[1] as a substitute for the term "abscess of the urachus." He based this designation upon the histologic evidence obtained from serial sections of the specimen of his case. A careful search of the literature fails to indicate another case similar to the one here to be reported; namely, a case of pyo-urachus rupturing into the groin and complicated by an urethral stricture. In 1931, Deneen and Margold[2] reported a case of urachal-cyst abscess, uncomplicated by stricture, which had ruptured into the peritoneal cavity.

The general consensus of opinion among anatomists is that the urachus takes origin from the ventral cloaca or bladder. In evidence of this origin is the similarity of the epithelial surfaces, and the muscular and fibrous coats of the urachus and bladder. Just prior to birth the bladder is situated in the region of the umbilicus and in its descent toward the symphysis pubis there occurs an outgrowth at its apex; and it is this tubular extension or outgrowth which is designated urachus. Among the chief exponents of this view are Robinson[3] and Felix.[4] Keith,[5] on the other hand, maintains that the urachus arises from the fetal allantois. This latter view was held until recent years. The remains of the allantoic stalk may be identified in the adult at the upper end of the urachus in the form of fibrous strands or cords (Luschka's plexus) which lie in the mid-line in association with the obliterated umbilical arteries. In the fœtus these strands pass through the umbilicus into the umbilical cord.

R. C. Begg[6] studied a series of twenty-eight urachal specimens from still-born fœtuses and from preserved cadavers which were obtained from the postmortem room. He demonstrated that the epithelial lining of the urachus never becomes completely obliterated to form a solid cord, but that its lumen or central canal persisted and in 33 per cent. of the cases communicated with the vesical lumen. Luschka[7] demonstrated that the urachus practically never reaches the umbilicus in the adult as a cord, but rather frays out into a number of fine thread-like strands before reaching that point.

The average distance from the bladder to the umbilicus is seventeen centimetres. The average length of the urachus is 5.5 centimetres. It is widest at its lower end, about eight millimetres, and at its apex measures approximately two millimetres. It is situated between the peritoneum and transversalis fascia, being more freely movable near its lower end where it is in contact with the bladder. At its upper end it is more firmly adherent

to the peritoneum and transversalis fascia. The blood supply is derived from one of the superior vesical arteries which courses along its ventral aspect.

As stated above, it is to be noted that the urachus, instead of being a completely obliterated cord, is actually a cord-like structure presenting a central canal which remains patent throughout life. At times, parts of the canal may become occluded with masses of desquamated epithelial cells. Should a direct communication exist between the lumen of the bladder and the urachus, these cells may be expelled into the bladder. At other times the canal may become segmentally blocked resulting in sacculations, and in the event of secreting cells existing in the lumen of the urachus, actual cysts may develop. Occasionally the epithelial cells show a tendency to spread laterally into the connective-tissue layers of the anterior abdominal wall, forming adenomatous-like structures, cysts and calculi. Organisms may enter the lumen of the urachus by direct extension from the skin or bladder, or they may be transported there through the blood-stream. In either event an infected urachus results.

The urachus with its lumen measuring approximately one millimetre in diameter extends from its upper end below the umbilicus down to the bladder where its lumen may communicate directly with that of the bladder. On the other hand, it may end blindly, losing itself in the submucosa or muscular layer of the bladder. A cross-section of the urachus in its most fully developed part would reveal several layers, the innermost consisting of irregular transitional epithelial cells surrounded by layers of loose and dense connective tissues which in turn are invested with a muscular layer. The adventitia which is also composed of fibrous tissue surrounds the urachus.

The normal urachus gives rise to no symptoms. It is, however, prone to pathologic changes such as infections, diverticula, calculus formations and new growths. Urachal disturbances occur more frequently in the male than in the female in the ratio of five to one (Squier and Cahill[8]). A review of the cases of pyo-urachus reveals the fact that in most instances there was a concomitant vesical or infravesical obstructive lesion such as a neoplasm, calculus, urethral stricture, prostatic hypertrophy, vesical neck contracture or median bar. In some of the reported cases, however, no evidence of obstruction could be ascertained. Where such an obstruction exists in the presence of a direct communication between the urachus and the bladder, a pyo-urachus is likely to develop. Urinary stasis is an important contributing factor in the formation of pyo-urachus. In cases where no direct continuity between the lumen of the urachus and bladder exists, organisms may be carried in by way of the lymphatics or blood-stream as demonstrated by Begg.

The diagnosis of pyo-urachus in the simple and uncomplicated cases can be made with little difficulty. The presence of a tender triangular-shaped mass in the hypogastrium accompanied by urinary disturbance such as dysuria, hæmaturia, pyuria, frequency and fever in the presence of a vesical or infravesical obstruction is extremely suggestive of pyo-urachus. Occasionally one

may find a few drops of urine at the umbilicus coming from the bladder by way of the urachus and Luschka's plexus.

Cystoscopic examination usually reveals the presence of a diffuse cystitis with a small reddened edematous area at the vault of the bladder which corresponds to the urachal opening. When pressure is applied to the suprapubic mass, one may note a ribbon of pus extending into the bladder from its vault. Occasionally one may be able to pass a fine catheter for a short distance through the urachal orifice. At times cystoscopy may reveal the causative factor in the production of the pyo-urachus. The higher incidence of this anomaly in males is presumptive evidence of the rôle played by obstruction in the formation of pyo-urachus. The diagnosis of pyo-urachus presents no unusual difficulties, especially when it is borne in mind that any cord-like structure extending from the symphysis pubis upwards toward the umbilicus may be due to a patent urachus.

It is not unusual for an infected urachus to rupture into the peritoneal cavity. Such cases were recently reported by Deneen and Squier. In the case of the former, the patient died of general peritonitis. A pyo-urachus may perforate through the umbilicus by way of Luschka's plexus and establish an external fistula, or it may rupture into the groin by burrowing through the fibromuscular and connective-tissue layers.

Treatment which is always operative should be instituted early. Complete extirpation of the tract including the peritoneum and umbilicus should be carried out in all cases. When the bladder is involved, as it usually is, the contiguous part of the vesical wall should be included in the extirpation. When infection has spread to the groin, wide-open drainage is indicated. The early institution of surgical intervention usually leads to recovery. Fatalities result from complications following failure to provide early drainage.

Case Report.—S. K., male, aged fifty-one, married, was first seen in consultation November 21, 1933, complaining of severe pain over the lower abdomen of three days' duration. One week prior to admission to the hospital he experienced a chill and rise in temperature with pain localized to the right groin. A physician who saw him at that time attributed the condition to inguinal adenitis resulting from a ringworm infection of the toes. He was put to bed and cold compresses were applied to the groin. The fever and chills, however, persisted. Three days ago the pain extended to the right iliac fossa and to the suprapubic region. It was noted that the pain was aggravated on motion and absent when the patient was lying on his back. There was no vomiting, but a history of constipation. Urinary symptoms were absent save for a slight frequency, every two hours. There was no history of cough, dyspnœa, or cardiac distress. The family history was essentially negative. About ten years ago he was treated for a gonorrhœal infection. During the past few years he had an epidermaphytosis involving both feet.

The patient was an obese male appearing acutely ill. Temperature on admission to the hospital was 104° F., pulse 118 and respiration 32. Examination of the head, neck and chest revealed no pathology. Blood-pressure was 130 systolic and 80 diastolic. There was a fulness to be seen in the suprapubic region; and the entire lower abdomen was tender and rigid. Rebound tenderness was elicited. The right inguinal glands were slightly enlarged but not tender. The liver and spleen could not be palpated. During catheterization it was noted that there was a filiform stricture of the membranous

urethra. Rectal examination showed no pathology. Urinalysis revealed a faint trace of albumin. Blood count: 15,300 leukocytes with 74 per cent. polymorphonuclears and 26 per cent. lymphocytes. Hemoglobin, 95 per cent. (Sahli).

Because of the history of ringworm infection with inguinal adenitis preceding the onset of the acute surgical abdomen, it was believed that the patient might have a suppurative adenitis involving the nodes of the pelvis and that this was responsible for the spasticity of the abdominal muscles. An internist, who was called in to see the patient, believed that he detected the greatest amount of tenderness and rigidity to the left of the mid-line, which led him to the conclusion that we were dealing with an acute diverticulitis of the sigmoid, and that the history of the preceding inguinal adenitis was purely coincidental. The necessity for an abdominal exploration was accentuated by the progressive increase in abdominal tenderness and rigidity, and a marked increase in leukocytes to 22,000.

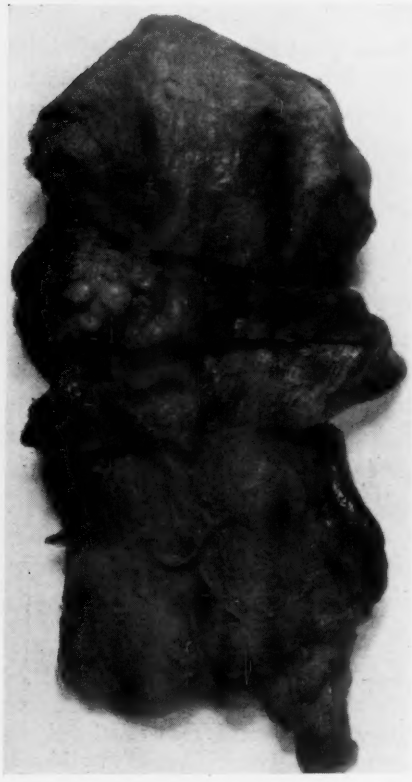

FIG. 1.—Gross appearance of specimen removed at operation.

Operation.—(J. A. L.) November 21, 1933, under spinal anæsthesia (tropococaine 10 per cent.) an exploratory laparotomy through a three and one-half inch mid-suprapubic incision was performed. Upon approaching the anterior parietal peritoneum, a large triangular mass was felt extending from the symphysis pubis towards the umbilicus, and attached to the anterior peritoneum. The peritoneal cavity was opened through an incision carried down to the right of this mass. Exploration of the sigmoid and pelvis showed no abnormality; the peritoneal cavity was not infected. Following closure of the peritoneum, the mass previously described was carefully dissected and on approaching its lower extremity pus was seen exuding from a small perforation in its lower portion and extending downwards towards the space of Retzius and outwards beneath the right rectus muscle towards the right groin. The bladder felt thick and indurated, and an attempt to aspirate it by means of a needle was unsuccessful. A catheter could not be made to pass into the bladder per urethram. The infected mass was stripped away from the bladder and space of Retzius. A specimen of the pus was taken for culture. An iodoform pack and two tubes were introduced into the space of Retzius and another tube was placed behind the right rectus muscle. The wound was closed in layers.

For seven days after operation the clinical course was uneventful. On the eighth day the patient was unable to urinate. He was catheterized but no urine was obtained. From that time his condition grew progressively worse. The abdomen became distended and he developed complete anuria which failed to respond to intensive treatments. He died in uræmic coma on the nineteenth day after operation.

Examination of the pus obtained at operation revealed a pure growth of *Streptococcus hemolyticus.*

Pathologic Report.—The specimen consists of a rectangular sheet of soft tissue (Fig. 1). It measures eight by five by four centimetres and is composed of a fibro-

FIG. 2.—Low-power photomicrograph showing the character of the urachal wall completely infiltrated with leukocytes.

FIG. 3.—High-power photomicrograph showing the wall of the urachus completely destroyed by leukocytic infiltration.

fatty outer envelope and is penetrated by a continuous canal running throughout its entire length. The canal is irregular and partly filled with numerous granular fragments of tissue. This cavity or canal in its widest part is two centimetres. A few small blood-clots were present within its lumen.

Sections show a uniform histologic picture (Figs. 2 and 3). There is a considerable amount of fatty tissue which is surrounded by a diffuse necrotic infiltration composed largely of neutrophilic leukocytes with an occasional plasma cell and a moderate number of mononuclear cells. There is a moderate hemorrhagic infiltration, and occasionally one sees a thickened vessel filled with erythrocytes. The fibrous connective tissue on which the fatty tissue rests is congested, edematous and riddled with inflammatory exudate.

SUMMARY.—(1) A careful review of the literature fails to reveal a single case of a pyo-urachus rupturing into the groin.

(2) The urachus is a developmental anomaly originating from the cloaca or bladder, and not the allantois.

(3) The urachus is prone to pathologic changes.

(4) The diagnosis of pyo-urachus is usually not difficult. A tender suprapubic mass accompanied by vesical or infravesical obstruction and urinary disturbance helps to identify this anomaly.

(5) Treatment is surgical and should be instituted as soon as the diagnosis is made.

CONCLUSIONS.—The case here presented is one of pyo-urachus associated with a filiform stricture of the urethra which had perforated and infected the space of Retzius and the right groin. The infected nodes felt in the groin, which were at first interpreted as being due to the epidermophytosis of the foot, were really secondary to the pyogenic infection which had extended behind the rectus muscle to the tissues of the right groin.

REFERENCES

[1] Stevens, A. R.: Pyourachus. Jour. of Urol., p. 319, September, 1933.

[2] Deneen, E. V., and Margold, A.: Urachus Cyst Abscess Rupturing into the Peritoneal Cavity. Jour. of Urol., vol. 25, p. 457, 1931.

[3] Robinson, A.: Cunningham's Text Book of Anatomy, p. 1314, 1922.

[4] Felix, Keibel and Wall: Manual of Human Embryology, vol. 2, p. 869, 1912.

[5] Keith, Sir A.: Human Embryology and Morphology, p. 390, 1921.

[6] Begg, R. C.: The Urachus; Its Anatomy, Histology and Development. Jour. of Anat., vol. 64, pp. 170–183, 1929–1930.

[7] Luschka: Ueber den Bau des Menschlichen Harnstrungs. Arch. f. Path. Anat. u. Phys. u. f. klin. Med., B.D., 1862.

[8] Squier, J. B., and Cahill, G. F.: Chronic Infection of the Urachus. Jour. of Urol., vol. 28, p. 607, 1932.

SYMPOSIUM

ON

CARCINOMA OF THE RECTUM

AT

THE FIFTIETH ANNIVERSARY OF THE MEMORIAL HOSPITAL

NEW YORK, N. Y. MAY 25, 1934

Chairman, GEORGE E. BINKLEY, M.D.

ETIOLOGY AND DIAGNOSIS OF RECTAL CANCER. EDWARD G. MARTIN, M.D., Detroit, Mich.

PATHOLOGY OF INTESTINAL CARCINOMA. JOSEPH FELSEN, M.D., New York, N. Y.

ONE STAGE ABDOMINOPERINEAL OPERATION FOR CARCINOMA OF RECTUM. THOMAS E. JONES, M.D., Cleveland, Ohio.

TWO STAGE OPERATION FOR CARCINOMA OF RECTUM. FRANK C. YEOMANS, M.D., New York, N. Y.

GOLD RADON SEEDS IN RECTAL CANCER. GEORGE E. BINKLEY, M.D., New York, N. Y.

EXTERNAL IRRADIATION IN RECTAL CANCER. JAMES J. DUFFY, M.D., New York, N. Y.

PREDISPOSING FACTORS AND DIAGNOSIS OF RECTAL CANCER

(A DISCUSSION OF ALLERGY.)

EDWARD G. MARTIN, M.D.

DETROIT, MICH.

AFTER the development of the first achromatic microscope at Paris in 1824, more than 40 years elapsed before the fundamental fact was proven that cancer was an atypical proliferation of epithelial cells. Records suggest that the Egyptians operated upon growths with hot cautery, and treated them with arsenical pastes in 1500 B.C. One thousand years later, Hippocrates described cancer in the breast and cancer of the internal organs. Galen founded experimental physiology and pathology about 200 A.D., and his opinion prevailed until late in the eighteenth century. Many theories were advanced as to the cause of cancer, and approximately 1,000 years passed before Galen's views, that strong black bile was the principal causative factor, were questioned. Virchow, who founded the science of cellular pathology, finally introduced the accepted conception of the histogenesis of tumors, and brought their study from chaos to an orderly science. His conception that cancer cells originated from connective tissue prevailed until Thiersch and Waldeyer disproved the theory in 1865–1867.

Heredity presents an intriguing study; however, after a review of opinions and quoted statistics, I am constrained to report that heredity in humans as regards the major forms of cancer, is as yet unproven. I say "constrained" because if cancer were hereditary, at least we might hope, by sterilization, to legislate it out of existence. In 3,000 cases from Middlesex Hospital, Hillier and Tritsch found a family history in 13.1 per cent, while the control group showed an incidence of 14 per cent. German statistics indicate even less, 9 and 10 per cent respectively in more than 9,000 patients—male and female. Much may yet be learned, however, about heredity.

Congenital or acquired predisposition, it seems to me, may be tentatively accepted and considered from an allergic or idiosyncratic standpoint. We do describe oil, tar, aniline dye, arsenic, roentgen ray and radio-active-substance cancers, also lung malignancies, ascribed to inhalation of various dusts. Under what seem identical circumstances, one person will develop carcinoma, while another does not. From 40 to 60 per cent of persons with multiple adenomata of the rectum develop cancer; why—no one knows. May the conception of allergy or idiosyncrasy be broadened to include this mysterious fact? If cancer develops as the result of a peculiar individual susceptibility, might that explain the confusion of false positives in some of the serodiagnostic tests? I confess incompetency to answer my questions. Hellwig[1] in discussing precancerous lesions states:

"No morphologic method can decide whether a noncarcinomatous atypical cell proliferation will actually develop into cancer or prove to be entirely harmless. The deciding factor, when such a lesion results in a malignant tumor, is apparently an individual predisposition, the nature of which is unknown."

While Rankin[2] in referring to adenomatous polyps says that:

". . . whether they are the result of inflammatory change or true neoplasm . . . after they reach a certain point in development and are subjected to certain (it must be admitted) unknown factors which initiate the malignant drive, (they) may result in identical processes which develop into malignant growths."

It is now generally conceded that rectal adenomatous polypi constitute the most dangerous, as well as the most common predisposing factors in the development of rectal adenocarcinoma.

Rankin and Fitzgibbon,[2] in 1931, traced thirteen of these cases through the sequence of events from a benign to a malignant condition, and reviewed the histopathologic characteristics of the polyps and were able to show conclusively that they were not all of a piece, but that in this series there was definite progression from benignancy to malignancy. They were divided into three distinct groups, varying grossly as well as microscopically.

In GROUP I, the epithelial elements were found to deviate little from the normal. The tumors are represented by rough, nodular elevations on the mucous surface of the bowel, varying in size from tiny clubs not much larger than a pin point to masses 2 cm. on cross-section. It is conceivable that this type of polyp may become malignant, but there is little evidence that it has a tendency to such change. It is interesting to speculate on the normal presence of such polyps in a bowel regarded as normal from the standpoint of function and symptoms. Certainly, such lesions are found most frequently in the mortuary, and lead one easily to the suspicion that a great many, perhaps most, colons, harbor such deviations from the normal mucosa.

In GROUP II, the polyps are distinctly different, not only grossly but microscopically. Their structural changes in both epithelial and connective tissue elements are abrupt, striking, and characteristic. The epithelial elements fail to differentiate into normal intestinal mucosa. The cells are elongated, and by their increased bulk are compressed laterally. Their arrangement may be in single rows, but frequently they are found pushed into multilayered buds, and project into the lumen of the tubules or into the connective tissue matrix. The nuclei are different in that they are more elongated than normal and are stained more deeply. As those epithelial proliferative processes progress, they stimulate a corresponding response in the connective tissue of the underlying growths, resulting in the production of a stalk which gives the polyp its pedunculated appearance. The time of the proliferation influences, according to its rapidity, the general anatomic scheme of the polyps, so far as the pedicles are concerned, making them large or small, and is, I

believe, an extremely important point in the metamorphosis of polyps to carcinoma. The carcinomata resulting from this group of polyps usually are of the pedunculated type, which, growing toward the lumen of the bowel and presenting themselves as piled-up masses of adenomatous tissue, may grow to huge size before malignant metamorphosis is completed. By their very presence they may be the initiating factor in intussusception or obstruction, thus calling attention to themselves. Fortunately, they usually are of a relatively low grade of malignancy or of average malignancy, one might say, and the prognosis, in that they do not project downward and backward to the nodal regions, is more likely to be favorable.

In GROUP III the polyps show almost complete failure of differentiation of their epithelium. In reality, GROUP III is an advanced and accentuated form of GROUP II. The proliferative epithelial element, which outpaces that of connective tissue, results in a complex polyp histologically, which usually is sessile and infiltrating. They may or may not attain large size and age, usually forming the smaller, more punched out, rapidly growing and metastasizing types of malignant growth. They proceed toward the peritoneal coat rather than toward the lumen, and in this way invade the nodal structures more often than the other types.

While excluding boldly other rectal and anal abnormalities or diseases, as not having any very important immediate bearing on the development of rectal cancer, Rosser's[3] observations suggesting anal pathology as an inciting factor in local tissue predisposition, should be mentioned. In a series of 13 cases of anal cancer, in 12 benign anal pathology was believed to have been present before the onset of malignancy and to have brought about a local tissue predisposition. The benign lesions present were fistulae (seven cases), hemorrhoids (four cases), infected crypts with papillitis (one case). In a subsequent review of eight cases of fistula, he believes that the criteria which he sets up warrant the assumption that they acted as an etiologic agent in inciting cancer.

It seems quite logical to exclude the anal region as of minor importance if one points to the comparative rarity of anal malignancy—perhaps two per cent, and what may be considered the almost universal occurrence of anal disease—perhaps 85 per cent. Rectal cancers are usually nearer the ampulla of the rectum than the anus, or at the rectosigmoid juncture.

Diagnosis.—Remarkable and most commendable study is being given to serodiagnosis; this study, however, remains unfinished, and the results so far inconclusive. The finding of the so called precancer lesion, the adenomata, is much more important than the discovery of the later carcinoma, since the treatment offers very much more favorable prognosis by less radical or devastating treatment. Although routine rectal examination (proctoscopy) may be more than can be expected, as yet, judging by current and past experience, it remains an undisputed fact that the majority of rectal cancers

could be prevented and cancer mortality tremendously decreased, if such a procedure were common practice. Proper digital examination will disclose the majority of rectal carcinomata, and were even this procedure common practice it will not be denied that cancer mortality would be tremendously lessened. By "proper," I mean that the patient should be required to "strain down," with the index finger inserted full length as though effort were being made to move the bowels; the rectosigmoid juncture can thus ordinarily be reached and explored. I inform students that if they feel anything except the smooth rectal wall, further investigation should follow; I also stress that hemorrhoids cannot be felt. When any complaint referable to the anorectal region is made and a physician fails to make a digital examination he is guilty of gross negligence. I would estimate that approximately 75 per cent of the profession are thus guilty, and so responsible for the large number of *advanced* cancer cases that are finally examined.

Mr. Ernest Miles of London believes that a latent period exists for a year or so prior to objective symptoms of cancer which is accompanied by a prolonged and well marked attack of constipation; that after an interval of from three to six months there follows diarrhea, slight at first and gradually becoming more pronounced. The constipation results from an induced inertia of the colon, and does not respond satisfactorily to treatment; there is no abdominal distention as in the later obstruction. Thus he defines in the Letsonian Lectures of 1923 this remarkable and now generally accepted prodromal symptom or sign—change in bowel habit.

Carcinoma at the rectosigmoidal junction rapidly involves the circumference and owing to the early stenosis produces obstructive symptoms. In the papilliferous variety there is excessive mucus secretion and diarrhea, becoming increasingly more marked; the stools are stained with blood, but real hemorrhage is unusual except as necrosis ensues. Obstruction finally follows as the result of impacted feces or local intussusception. The adenocarcinoma rapidly infiltrates the entire circumference and announces its presence by obstruction, often without bleeding or diarrhea.

Carcinoma in the Ampulla.—When discovered early, it is by incidental or routine examination since the growth causes no subjective symptoms at that time. In the occasional exuberant papilliferous variety, the sensation of fullness may excite attention; this may occur before any sign, such as a copious mucus discharge, appears; blood comes into the picture with surface disintegration. The adenocarcinoma, by far the more frequent and more malignant, involves the mucous and submucous membrane; it usually appears as a sessile growth and is at first freely movable, but after a few months infiltrates the muscular wall. Surface ulceration occurs with increasing growth and the flattened surface finally yields, and the crater-like ulcer develops. With the spread of this destructive ulceration, the usual subjective and objective symp-

toms develop, with frequent mucous stools tinged with blood and having the characteristic foul odor of rectal cancer. I have examined patients in whom the crater-like ulcer had involved almost the entire excrescence of the tumor; then I have found the crater plastered with fecal matter, leaving a smooth and confusing surface. It is somewhere in this stage that the patient and his doctor conclude that something besides suppositories ought to be done about his "piles."

In explanation of some of the symptoms it may be stated that hemorrhage at this stage is usually due to accompanying hemorrhoids except where a vein may have ruptured by necrosis; the excessive mucus is due to proctitis and the odor to necrotic tissue mixed with blood and mucus. Pain during and after defecation indicates encroachment into the anal canal. "Dull ache" describes the later pain of a midampullary carcinoma. Frequent stools occur in the daytime owing to the upright position.

Anal carcinomata, although frequently mistreated for anal ulcer, cause such early and excruciating pain that they are usually presented for examination while still operable. This is the most infrequent location of the rectal cancer; the diagnosis obviously should not be difficult.

Differential Diagnosis.—Confusion may result when an intussuscepted papilliferous colon growth is discovered in the rectum; since the tumor is not attached to the rectal wall, although it may conceivably fill the rectum, its source should thus be determined. Miles describes the villous papilloma as feeling like a mass of mucous membrane; an exuberant growth attached to the rectal wall by a narrow hand-like pedicle extending from one end of the growth to the other, at times resembling attachment as by a mesentery. It has a characteristic watery secretion necessitating frequent evacuation. I have seen but two such growths. A simple adenoma is soft, nonindurated, and finely lobulated, while the malignant adenoma is indurated and feels generally firm on digital examination. They may be pedunculated or sessile.

The value of biopsy in diagnosis is not now debatable. If positive for malignancy, its value for prognosis involves the disclosure of histogenesis, degree of malignancy, radiosensitivity, and perhaps metastasizing possibilities. Discussion of biopsy should be an essay in itself, and I will simply emphasize that aseptic and antiseptic precautions should be observed. It is advisable to excise the entire suspected area when practicable, thereby accomplishing the double purpose of eradication and diagnosis. A specific or differential stain for cancer would be of inestimable value and simplify pathologic diagnosis; it is an objective well worth the efforts being made to attain it.

In summarizing, may I say that the adenoma is, within our limited knowledge either the principal agent or the principal factor predisposing to rectal cancer, and that the responsibility for reduction in the mortality from rectal cancer lies with the average physician. Thoughtful consideration

should be given the hypothesis that cancer results from an individual susceptibility to an unknown factor which initiates the pathological process.

REFERENCES

[1] Hellwig, C. Alexander: Arch. Pathol., vol. 14, pp. 517–554.
[2] Rankin, Fred W.: Surgical Lesions of the Large Bowel. Jour. Mich. State Med. Soc., vol. 31, No. 1, 1931.
[3] Rosser, Curtice: Etiology of Anal Cancer. Amer. Jour. Surg., vol. 11, p. 328, 1931.

THE PATHOLOGY OF INTESTINAL CARCINOMA

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THE close relationship of the adenomatous polyp to carcinoma of the large bowel has been stressed by many authors, some of whom are of the opinion that all carcinomata of the colon or rectum originate in polyps (Versé, Westhues, Fitzgibbon and Rankin). Without entering into any controversial discussion, this viewpoint has been misconstrued by many to indicate that all polyps tend to become malignant. This is certainly not true, for multiple, silent, benign polyps of the large bowel are relatively frequent if carefully sought for at the autopsy table. The condition of diffuse polyposis of the large bowel, which may perhaps be more properly referred to as adenomatosis coli, appears to have an underlying pathogenesis different from that of the simple isolated polypoid adenomata. There is a definite familial character of the Mendelian type and a distinct tendency to malignant degeneration, often of multicentric character. In some cases adenomatosis coli appears to be an exaggerated response of the intestinal mucosa to an irritant, possibly infection, taking the form of multiple, closely packed, focal areas of epithelial hyperplasia. In an excellent example of this disease, involving the entire colon, the earliest lesions appeared as slight localized thickenings of the mucosa, often not larger than a pinhead, flat, and scarcely visible to the naked eye. Pedicle formation occurs at a late stage when the adenoma is quite fully developed, though still very superficial. The intestine attempts to expel the tumor as it would a foreign body and thus by reason of a loose mucosa, the adenoma acquires a pedicle, often of surprising length. Polyps with long pedicles rarely become malignant. Those with very short pedicles quickly become sessile, flat, and broad, when malignancy supervenes. I have never seen disappearance of coexisting benign polyps after removal of a carcinoma. In reviewing the general subject of intestinal tumor pathology, one cannot but be impressed with the fact that simple polyposis as well as adenomatosis coli seems to occur in intestines which possess underlying pathologic tendencies. Thus,

one may see such associated conditions as villous tumor, diverticulosis or congenital anomalies.

Classification of carcinomata of the rectum into projecting, infiltrating and stenosing types is simple and practical, but these often represent different stages in the same pathologic process. As a general rule, the projecting types are fairly slow growing and are prone to undergo necrosis, but tend to remain local and rather superficial. Most Grade I tumors are of this type. The infiltrating and stenosing carcinomata tend to be more anaplastic. Mucin production is no certain criterion of the degree of malignancy. It merely represents an exaggerated physiologic activity of mucus-producing cells in cancerous tissue. Metastases do not alway conform to the general rule of intestinal carcinoma—*i.e.*, the tendency to maintain the same structural type as the original tumor. I have not infrequently seen marked anaplasia in metastases, making it impossible to identify the site of the original, well-differentiated tumor. Briefly, it may be stated that the growth of intestinal carcinomata is relatively slow, depending, of course, upon the degree of anaplasia. In general, it may be said that carcinomata in the colon are more anaplastic than those in the rectum. With increasing anaplasia, there is a tendency to earlier age incidence and greater radiosensitivity, but a correspondingly poorer prognosis with regard to duration of life.

The grading of biopsy material should be done with caution. It is advisable to take specimens from (*a*) the growing edge, (*b*) the ulcerated floor, (*c*) the superficial projecting portion of the tumor in each case. In papillary tumors, especially, the biopsy must be taken from the base. I have repeatedly noted discrepancies in grading specimens taken from different portions of the same tumor and in one papillary tumor, there was no histologic evidence of malignancy, thought grossly carcinomatous, until a section was taken from the base.

Lymphatic extension may occur in any grade after the neoplastic process has reached the submucosa. Within the gut wall this occurs in two ways: annular, by involving the large circular intermuscular lymphatic plexus, and by wedge shaped extensions towards the peritoneum. Enlarged lymph nodes, though often inflammatory, should always be viewed with suspicion, especially in the nonulcerative types of tumor. The pathologist must dissect away the epiploic fat and feel for involved nodes with ungloved fingers, as otherwise they may be overlooked. There is a certain similarity between carcinoma and ulcerative disease of the intestine, such as bacillary dysentery, amebiasis and tuberculosis. In all, the lymphatic structures are extensively involved and serve as channels for dissemination of the disease. The tendency for tuberculosis to produce girdle ulcers is duplicated by the annular type of intestinal carcinoma because in both the circularly disposed intermuscular lymphatic plexus is involved. The chains of lymph nodes affected follow

the same anatomic course. Undermining of the mucosa in amebiasis suggests that type of carcinomatous growth in which the neoplasia starts at one point on the mucosa, spreads along the submucosal lymphatic plexus and reappears on the mucous membrane at some distal point.

Occasionally a patient with a liver nodule may live for years after resection. Metastases are most frequent from tumors of the rectum, sigmoid and proximal colon. The last is relatively poor in lymphatics, except at the cecum and sigmoid. In carcinoma of the transverse colon, omental metastases may occur. And, finally, carcinoma of the lower rectum (columnar, intermediate and cutaneous zones) may metastasize to the inguinal nodes.

Primary Tumors of Large Intestine

(Jan. 1, 1932 to May 1, 1934)

Carcinoma—32:

(A) Rectum—16:

Grade I	6	(age 32–65)
Grade II	8	(age 37–59)
Grade III	1	(age 50)
Grade IV	1	(age 40)

(B) Sigmoid—9:

Grade I	2	(age 61, 67)
Grade II	3	(age 45–74)
Grade III	2	(age 36, 44)
Grade IV	1	(age 36)
Ungraded	1	(age 57)

(C) Colon—7:

Cecum	2	Grade II	1	(age 56) Mucinous.
		Grade II	1	(age 70) Mucinous.
Hep. flex	1	Grade II	1	(age 34)
Trans.	1	Grade II	1	(age 54)
Splenic	2	Grade I	1	(age 72)
		Grade III	1	(age 26) Death in 14 months.
Desc.	1	Grade III	1	(age 44) Multicentric. No recurrence 18 months.

Other primary tumors—8:

(A) Multiple adenomata—3:

164 Autopsies: Multiple polyps in 3 of last 63 autopsies, one associated with diverticula of sigmoid, one with submucosal lipoma.

(B) Papilloma—1:

Anorectal.

(C) Tumors of appendix—4:

Cavernous hemangioma	1
Embryonal lipoblastoma	1
Carcinoid	1
Mucocele	1

THE ONE STAGE ABDOMINOPERINEAL OPERATION FOR CARCINOMA OF THE RECTUM

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MANY considerations enter into the development of a surgical procedure aimed at the eradication of malignant disease of the rectum. First to be considered is the age and general condition of the patient; second, the extent of the process; next, the hospital facilities; and lastly, the ability and experience of the surgeon. As a general rule the surgeon should do the type of operation at which he is most adept and for which the facilities at hand are most adequate. However, if this rule were too strictly adhered to, it is quite evident that surgeons would adopt an attitude of *laissez faire* and would not extend themselves to accomplish improvements in technic. This is well exemplified when one reviews the history of the various surgical procedures applied to carcinoma of the rectum. In its evolution, of course, developments in anesthesia, bacteriology, physiology and chemistry, as well as improved hospital facilities, have further aided the surgeon in accomplishing a great deal for the unfortunate patient with cancer.

I shall discuss here only the one stage, combined abdominoperineal operation, whose chief protagonist is Miles, of London. The operation is admittedly severe, but it is not intrinsically difficult nor does its performance demand any exceptional ability. Miles was led to believe in the superiority of this procedure after a long experience with all types of operations and extensive study on the mode of extension and sites of recurrence following operation. Operations for cancer in any location necessitate thorough knowledge of the lymphatic system, and this is especially true so far as the rectum is concerned. Miles has given us a most lucid description of the lymph nodes in the rectal area.

Advocacy of any new procedure must be defended by thorough knowledge of fundamental principles, but space does not permit here any lengthy discussion of the relative merits of the one stage or two stage operation, except to point out that in the final analysis the only argument in favor of the two stage operation is the lower rate of operative mortality. It should be pointed out, however, that if a surgeon has 100 patients, he is really performing 200 operations and no surgeon is lucky enough to be immune from accidents beyond his control. Furthermore, mortality from the two stage operation is quoted only after the second stage is completed, so that if the patient dies from the colostomy operation, this is not reckoned in the statistics because he has never reached the second stage of the operation. The mortality of colostomy averages 4 to 5 per cent; if this number were added to the second stage where statistics of mortality often rightly belong if the two operations are to be compared on a fair basis, it is my feeling that the rate of mortality for the one stage and the two stage operations will be approximately equal.

An appropriate analogy, it seems to me, can be drawn from the field of thyroid surgery. Ten years ago, thyroidectomy for hyperthyroidism was a two, three or four stage procedure: the vessels were ligated first and the patient returned in two or three months for operation. Now with the use of Lugol's solution, the patient is prepared for operation in about ten days and the operation is done in one stage with an even lower mortality than previously.

So with the one stage operation, the largest individual factor is preoperative treatment which is so essential to its success, yet so little attention is paid to it. If the medical management is carried out thoroughly it will accomplish as much in preparation of a patient as will colostomy.

After the diagnosis of cancer of the rectum has been made, a thorough physical examination, of course, is essential. This is just as important as it is to have the physician do a digital examination of the rectum. A thorough search must be made for metastases and in a certain number of cases these can be seen (by the cachectic appearance of the patient) before they are felt. I believe that with the more widespread use of intravenous dyes, liver metastasis can be discovered in many instances, thus saving the patient from exploratory operation. If no contraindication to operation is found, the patient is hospitalized and preparation is begun.

Most of these patients have had more or less chronic obstruction for weeks or months and a drastic cathartic is contraindicated. I advise magnesium sulphate, one ounce of crystals in eight ounces of water, the patient to take one-half ounce of the mixture every half hour. This is repeated each day up to the day before operation. Magnesium salts are slightly irritating and cause fluidity of the stools by nonabsorption of water. They also stimulate peristalsis and make an ideal laxative for these patients. In addition, enemata are given each day. After three or four days of this routine the distended abdomen frequently becomes scaphoid. Lately in addition to the above measures, pitressin has been used with gratifying results. In order to make up the loss of water through the intestine the patient is encouraged to drink large amounts of orange juice, lemonade and water and, if necessary, hypodermoclysis is administered.

Because, for many weeks, the patient's appetite has been poor, it is likely that a considerable portion of the glycogen reserve in the liver has been exhausted. Hence 500 cc. of a 10 per cent solution of glucose are injected intravenously each day. The patient takes a high caloric, nonresidue diet. During his stay in the hospital the kidneys are investigated and estimation of urea clearance is made. Because of the age of many of these patients, there is an associated hypertrophy of the prostate, with obstruction and retention and consequent damage to the kidneys. Several patients in my series have had to have a punch operation of the prostate after recovery from the rectal resection. Overlooking a condition like this may readily prove disastrous, and if such a condition exists, the patient should have catheter drainage similar to the treatment preliminary to prostatectomy.

The impoverished myocardium usually improves with the increased glucose intake, but in case it does not, digitalis may be given for several days before the operation. During these preoperative days attention is given also to mouth hygiene. If the patient's hemoglobin or red blood cell count is low, a transfusion is given before, as well as after, operation; if the blood count is normal, the transfusion is withheld until after the operation in order to combat shock. Obviously the routine is entirely different from that in vogue not so many years ago, when the patient was brought into the hospital one night, given a dose of castor oil and operated upon the next morning.

After the patient has been well prepared for operation, anesthesia is the next important consideration. From my experience spinal anesthesia is to be preferred for its advantages far outweigh any disadvantages it may have. The relaxation and quiet abdomen are conducive to a more rapid performance of the operation and the fact that the anesthesia lasts only about an hour and a half is further stimulus to the surgeon to have things well planned and not to loiter, a habit too easily acquired if the patient is deeply anesthetized. There is not much choice in preparations used for spinal anesthesia today. In my experience, 150 to 200 mg. of Pitkin's solution has been used successfully in more than 3000 operations. Meticulous care is taken to observe the blood pressure, although many observers say it will always come back to normal even after marked depression. This may be true but the complications in the succeeding few days, it seems to me, have a direct relation to that insult at operation. The use of ephedrine has been boosted and condemned. Increasing the blood pressure as it does by increased cardiac output may be of doubtful value because the drop in blood pressure is caused by vasomotor paralysis. At present I resort to the use of epinephrine only when the patient's systolic blood pressure falls below 80. The argument that the action of epinephrine lasts only for a short time is not tenable, for the operation itself lasts only a short time. With a few injections of one-half cc. of epinephrine from time to time its effect will last until the anesthesia has disappeared.

As soon as the anesthetic has reached the level of the umbilicus, the patient is placed in the Trendelenburg position and prepared for operation. The various steps in the operation are simple and straightforward and are well within the capacity of any one possessed of average skill who knows what he wants to do and how to proceed. A long midline or left rectus incision is made and the liver is examined for metastatic involvement. Multiple nodules preclude operation; a small solitary nodule may not contraindicate operation for in such a case the patient may live two or three years and is much more comfortable if the primary growth is removed. The pelvis is then examined as to fixation or extension of the growth to the bladder or pelvic peritoneum.

If there is no contraindication to operation the first step is to incise the peritoneum on the lateral wall of the sigmoid at about the level of the pelvic brim. This fold is quite variable but it is usually necessary to incise it in

order to mobilize the sigmoid. Then the inferior mesenteric artery is identified; the Cameron light is very useful for this purpose except when there is considerable fat in the mesentery. In the latter type, the artery generally is situated in the mesentery about two inches below the bifurcation of the aorta. This is tied just below the point where the first sigmoid branch emerges: it is necessary to preserve this for the blood supply of the sigmoid. Isolation and ligation of this artery saves a lot of time which otherwise would be consumed in cutting and tying down vessels throughout the length of the mesentery. Then the peritoneum is incised on each side of the mesosigmoid down to the floor of the pelvis, anteriorly to the rectovesical pouch in the male or the pouch of Douglas in the female. The next step is to place the hand at the promontory of the sacrum and to separate all the fat from the hollow of the sacrum and push it forward. This dissection is carried down until the coccyx is felt. Attention is then directed to freeing the intestine anteriorly. A wide ribbon retractor is placed behind the bladder and with a long blunt scissors the dissection is carried down till the seminal vesicles are recognized. These are then pushed forward until the prostate can be felt, or, in the female patient, until the vagina is seen.

With the anterior and posterior dissection complete, traction on the bowel renders prominent the rectal stalks which support the rectum and these are divided as far laterally as possible; on the completeness of this dissection depends to a great extent the patient's curability and also the ease of posterior resection. The next step is dividing the bowel and the point of election depends on the redundancy or brevity of the sigmoid: if it is long, it is divided at a convenient point and brought out through the original abdominal incision for the permanent colostomy; if it is short it is brought out through a left McBurney incision. The bowel is divided by cautery between two crushing clamps and is tied with a heavy silk suture. Over each end is placed a piece of rubber dam which, again, is tied over the bowel. This saves time and prevents contamination by trying to invert the ends by purse string sutures. The distal loop is then placed in the pelvis and the pelvic floor is reconstructed. This is made from the flaps of peritoneum from the sides and floor of the pelvis and the posterosuperior surface of the bladder. If an opening remains it is repaired by placing an omental graft over the hiatus. This seldom is necessary. After closure of the incision with the colostomy either in the midline or left iliac region, the abdominal part of the operation is complete.

The patient is then placed on his abdomen in the Kraske position. A purse string suture is placed around the anus and an incision is made in the midline from midsacrum down to and encircling the anus. If the growth is low, a good portion of perianal skin must be taken. The skin flaps are dissected laterally until the gluteus maximus is seen. The coccyx is then disarticulated at the sacrococcygeal joint and the pelvic cavity containing the dissected colon is entered. The rectum is next dissected from above downward. The prostate or vaginal wall is in plain view and after the levator ani

are incised (as far laterally as possible) removal including the fat in the ischiorectal space, may be quickly accomplished.

There remains a large cavity surrounded only by the bladder in front and the bony wall of the pelvis. A large rubber square is placed into the cavity and this is packed with gauze to stop the oozing and to help support the new pelvic floor. The incision is then closed except for a distance of two inches, where the drain is situated. The gauze is partly removed on the second, third or fourth day and the cavity is irrigated daily with solutions of sodium chloride or boric acid or a 1 to 8000 solution of bichloride of mercury. After this the patient is put to bed and a blood transfusion of 500 cc. of blood is administered.

Postoperative treatment then is symptomatic. The colostomy is opened on the second, third or fourth day, depending on the degree of abdominal distension. The patient receives a full diet as soon as the colostomy is opened.

If there are no contraindications, the patient is encouraged to get out of bed on about the twelfth to fourteenth day after operation. This helps to make the new pelvic floor sag, thereby hastening the filling of the large cavity. Before the patient returns home, he is instructed regarding irrigation of the colostomy and other general care.

I believe that properly planned and executed, this operation offers the best hope of cure of cancer of the rectum. The operative mortality rate in 135 cases is 11 per cent.

The percentage of patients with five years' immunity from carcinoma is 52; with three years' immunity, 62 per cent; and 67 per cent of this group have been well for less than three years.

TWO STAGE OPERATION FOR RECTAL CANCER

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RADICAL surgery of rectal cancer has now attained such a degree of technical perfection that it would seem that slight, if any, advance in operative technic can be looked for.

Contributing factors have been improvement in the preoperative survey and preparation of the patient, postoperative care, and above all the selection of the type of operation best suited to the individual case.

The operative maneuvers have become clearly defined and standardized into the following types:

(1) One stage abdominoperineal operation.
(2) Two stage abdominoperineal operation.
(3) Two stage perineal excision.

(4) Posterior resection.
(5) Perineal amputation.

This classification implies that the surgeon undertaking this type of surgery should be familiar with, and skilled in, the performance of each of these operations as indicated.

The one stage abdominoperineal operation, as perfected by Miles, with permanent terminal sigmoidostomy and removal of the entire segment distal to the stoma, is the ideal from the standpoint of wide eradication of the disease and prevention of recurrence. Indeed, this wide excision is the only practical procedure when the rectosigmoid is involved, as it is in approximately 60 per cent of cases. Experience has shown, however, that the same radical removal can be accomplished with less risk by dividing the operation into two stages, namely, a preliminary colostomy to be followed in a fortnight or longer by the excision.

Pioneers in the development of the two stage operation are W. J. Mayo (1912) who did a loop colostomy, ligated the blood supply to the rectum and closed the ends of the pelvic colon sectioned distal to the colostomy, burying the aboral, devitalized segment beneath the closed peritoneum, to be removed extraperitoneally at the second stage. In 1915, Daniel Fiske Jones proposed a loop colostomy with central ligation of the sigmoid vessels, thus preserving the vascular arches from the left colic artery and blood supply to the distal segment; freeing the rectum on all sides and suture of the dissected pelvic peritoneum to the sigmoid above the point of central ligation of its vessels and above the tumor. The loop colostomy facilitates cleansing of the distal segment by irrigations before the second stage which is an extraperitoneal procedure. Inversion of the proximal end of the bowel at the second stage, however, leaves an undesirable blind pouch distal to the colostomy. In 1932, Jones reported his operability as 60 per cent, operative mortality, 20.7 per cent; operated patients alive at three years, 73 per cent; and at five years, fifty per cent, or 26.2 per cent of total cases seen.

Coffey, in 1914, published a procedure the chief object of which was to protect the peritoneum from infection. It accomplishes this aim very effectively. In the first, which is the major stage, the sigmoid is divided and an end colostomy is established, the distal vessels are severed, the distal pelvic colon and the rectum are dissected and the peritoneum closed in such manner that the lower portion of the peritoneum of the abdominal wound is united to the margins of the pelvic peritoneum disserted from the pelvic colon. The distal segment of colon is inverted through the rectum; in women, through the posterior vaginal fornix, beneath the closed peritoneum. Large cigarette drains, inserted to the bottom of the pelvis, emerge through the lower angle of the abdominal wound.

At the second stage, ten days later, the distal segment and rectum are removed from below by wide dissection. Due to the considerable dissection and suturing required, the first stage is comparatively long while the second

stage is short. This operation, like that of Mayo, has the disadvantage of leaving, between stages, devitalized bowel with poor drainage in the freshly denuded pelvis. Dudley Smith modified Coffey's technic of the first stage by complete closure of the abdominal wound and inserting rubber dam drains through an incision lateral to the coccyx.

At the twenty-third annual Clinical Congress of the American College of Surgeons, Coffey reported that a total of 239 cases of carcinoma of the rectum and rectosigmoid had been admitted to his clinic. Radical removal was done in 31 cases of rectosigmoid growth, hospital mortality seven (22.5 per cent); and in 82 cases of carcinoma of the rectum by his "inversion technic" hospital mortality six (7.3 per cent). Fifty-one patients were traced, of whom 23 died before the end of five years. Of the 28 who survived over five years, 13 died, two only of recurrence; and 15 were alive without known recurrence from 5½ to 15 years after operation.

My own experience with Coffey's method in a single case was no infection of the peritoneal cavity, a stormy convalescence, but a very satisfactory result.

Mr. A. H., aged 52 years, had a large carcinoma beginning three and one-half inches above the anus on the anterior rectal wall and involving the rectosigmoid. The first stage was performed on June 8, 1925. Colostomy was established and the tumor bearing segment removed through the abdomen. Twelve days later the second stage perineal excision was carried out. Now, nearly nine years later, the patient is in excellent health. His colostomy functions well, his weight is the highest it has ever been and he follows his usual occupation without discomfort.

The next steps in the evolution of the two stage operation and the nearest approach to the one stage ideal procedure were advanced by Rankin and Lahey. Both procedures have the virtue of preserving the blood supply of the distal segment until the second stage excision.

Rankin, in 1929, advocated as the first stage an end colostomy, dropping back into the peritoneal cavity the closed distal end of the divided sigmoid, and preserving intact the blood supply of the distal segment. As a consequence, the second stage may be deferred as long as seems beneficial for the improvement of the patient's condition, rectal irrigations being given meanwhile. At the second stage the rectum is dissected from below, encased in a rubber glove, and the entire rectum and distal sigmoid removed through the abdomen. In 1934 he reports that in a series of 85 cases there were eight operative deaths, a mortality of 9.5 per cent. Of 300 cases of carcinoma of rectum and rectosigmoid operated upon in a total group having an operability of 50 to 60 per cent, 114 or 38 per cent, were alive and free from recurrence at the end of five years.

In 1930, Lahey modified the first stage of Rankin's method by fixing the distal segment of the divided sigmoid colon into the lower angle of the abdominal wound, thus affording an easy and efficient way of irrigating the distal segment. A practical difficulty may be experienced in obese subjects in bringing the distal end of the sigmoid to the skin surface and in retain-

ing it there when the mesosigmoid is short. A minor disadvantage in the second stage is that the infective stoma must be closed just before opening the peritoneal cavity, dissection of the pelvic colon and rectum, and removal of the entire distal segment from below. Lahey (1934) reports that he and his associates have employed this method in 29 consecutive cases without an operative death.

The advantages of the two stage over the one stage abdominoperineal procedure are its greater safety and its applicability to cases in which the one stage operation would be too great a hazard. Between stages, function of the colon is established, a notable degree of rehabilitation of the patient is accomplished, nutrition improved and toxemia reduced. Moreover, irrigation of the distal loop cleanses it of feces, renders the ulcerated carcinoma comparatively free from infection and, as a consequence of the reduction of inflammation, the tumor bearing segment is frequently shrunken and so more easily and safely removed at the second stage.

The two stage perineal excision for tumors of the rectum proper justly merits the popularity accorded it, especially by British surgeons. At the first stage the abdomen is explored and a loop colostomy established. About two weeks later, during which the distal segment has been irrigated and the general condition of the patient improved, the distal segment is removed through the perineum at a safe distance above the tumor, and the proximal end inverted by a double row of sutures.

Miles abandoned this procedure after recurrences in 94.4 per cent of the patients in which he had used it. Nevertheless, Gabriel's statistics of 370 cases of posterior resection by the surgical staff at St. Mark's Hospital are impressive. Of 189 cases operated upon (1910–1926), 55 or 36.4 per cent survived five years without recurrence. Of 91 cases operated upon (1910–1921), 20 were cured on a ten year basis, *i. e.*, 30 per cent. In both series the "untraced" and those "dead from other causes" are excluded in estimating the results.

The chief advantages of the two stage perineal excision are its safety in poor risks, in anemic and weak individuals, in very obese subjects and in patients having cardiorenal complications, conditions which bar the more hazardous one stage procedure. Where applicable, the two stage posterior resection is the safest operation in the hands of the average surgeon.

Posterior resection implies dissection of the lower pelvic colon and rectum through the abdomen; posterior removal of the coccyx, possibly with a portion of the lower sacrum, delivery of the tumor bearing segment of bowel through the wound, its division above and below the growth and circular suture of the ends. As an alternative, the upper segment is drawn through the previously denuded anal canal after the method of Hochenegg. Posterior resection involves an exacting and difficult technic and is employed by very few surgeons. Its complications are infection and later stricture or fistula at the site of the circular enterorrhaphy. Recurrences are frequent.

Perineal resection (amputation) of the rectum without colostomy should be reserved for neoplastic involvement of the anal canal and lower rectum in which the finger, introduced per anum, reaches the upper margin of the growth. If the roentgen ray shows a freely movable sigmoid colon of average length, as much as six to eight inches of bowel can be brought down and amputated, and a new anal outlet established at the normal site. This is an excellent operation in obese patients and in the aged, and in females especially its accomplishment is technically easy.

My personal experience with perineal resection has been quite extensive and in general very satisfactory both as to immediate and late results, including control of the feces. Several patients have lived in comfort and without recurrence over five years, one more than ten years after operation.

GOLD RADON SEEDS IN RECTAL CANCER

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SELECTION of the most appropriate treatment for a given case of rectal cancer may be an easy or difficult problem. There are many variable factors to be considered at the time the disease is recognized. Analysis of these factors varies widely. They may suggest a hopeless condition or possibility of a clinical cure. Experience has proven that best results are obtained when each case of rectal cancer is considered a separate problem and treated in accordance with clinical and pathologic factors.

Treatment of cancer is a surgical problem. Different methods of surgical technic are advantageous. Radium and roentgen ray should be considered additional surgical equipment. In our clinic we employ the one and two stage abdominal perineal operations; the perineal extirpation usually preceded by a colostomy and radiation therapy. Radiation therapy is used alone, as a palliative measure, and in selected cases to promote clinical cures. The physical agents are also at times combined with colostomy and radical surgical removal.

Implantation of gold filtered radon seeds into the tumor mass constitutes one form of interstitial irradiation. The method may be used separately, as the only form of radiation therapy, but usually it is combined with preliminary external irradiation. Radon seeds are a means of delivering sublethal and lethal dosages of radon to malignant cells. The field of irradiation is largely limited to the tumor mass, there being only a moderate effect upon the rectal mucosa and surrounding tissues, provided seeds are not inserted beyond malignant areas. By varying the number and strength of seeds, large, as well as small, tumors may be influenced.

Gold radon seeds consist of radon encapsuled in a small gold tube. The seeds are four to five Mm. long, 0.75 Mm. in diameter with a three-tenths thickness of gold. The glass filter of the radon seed was replaced by gold in

1925. The strength of seeds varies from one-half to three millicuries each. They are implanted into the tumor mass by trochar needles and left in place. A number come to the surface and are discharged, while others remain *in situ* for years.

Technic of application is of utmost importance. It is upon this factor together with selection of total dosage and strength of individual seeds, that ultimate results largely depend. It is not, as many of the unexperienced believe, a simple procedure to adequately irradiate a cancer situated in the rectum. There is much more to this operation than merely inserting haphazardly a number of radon seeds. In order that the disease may be eradicated sufficient dosage must be delivered to every malignant cell to cause devitalization. At the same time surrounding normal tissue should be spared unnecessary damage. Adequate interstitial irradiation is facilitated by careful estimation of the size, shape, thickness, degree of radiosensitivity, *etc.*, of the tumor. Such factors permit calculation of the required total dosage and the selection of the individual strength and distribution of the seeds. The operation of implantation ought to receive equal consideration to that afforded surgical extirpation of the rectum. When the case is a favorable one, the objective is the same in both instances, namely, a clinical cure of the disease.

Patients are selected for radiation therapy after careful examination and appraisal of the clinical and pathologic factors. These factors are such as to separate patients into favorable and unfavorable groups. Usually those selected for radiation therapy, whether they be favorable or unfavorable, receive preliminary external irradiation. Following completion of the external irradiation patients are admitted to hospital for interstitial implantation. The rectum is cleansed by irrigation or castor oil. Insertion of seeds is carried out in a suitably equipped operating or treatment room. Anesthesia is required in only a small percentage of cases. In many instances, it is an advantage not to have the patient under complete narcosis. All seeds are threaded into trochar needles and made available for use before the operation is commenced. This shortens the length of time required for the patient to remain quiet in one position. Patients are placed in the position which on previous examination was found to give best view and greatest accessibility to the tumor. The knee chest and dorsal are the most frequently employed, but occasionally the lateral position offers additional advantages. The implantation is made in most instances by direct vision through an electrically lighted proctoscope. Bleeding is seldom troublesome. The operative field is kept clean when necessary by the aid of a suction apparatus.

The proctoscope is first passed beyond the tumor and is then withdrawn until the upper limits of the cancer come into view. This upper area is implanted with seeds. They are placed three-quarters to one cm. apart depending upon their strength. The protoscope is then withdrawn for about one cm. and another row of seeds implanted. This procedure is repeated until the whole tumor has been implanted. Thickness of the malignant area largely determines the strength of the seeds. When possible, seeds of sufficient

strength to affect the whole thickness are employed. Occasionally in very thick tumors a double layer of seeds is necessary. Tumors of the lower rectum may be treated with the finger placed within the rectum to guide the distribution of seeds. The needles may be inserted by way of the anal canal, perineum, and in females through the posterior vaginal wall. Radiation therapy is a selective method of treatment. It may be used alone or in combination with surgery. An attempt will be made to show the value and advantage of implanting gold seeds in certain types of rectal cancer.

Our greatest experience in radiation therapy has been with the inoperable group of cases. External therapy is advantageous to all advanced cases that remain ambulatory and are able to take treatment without hospitalization. Interstitial radiation is suitable for only about 50 per cent of the advanced cases, namely, those in better physical condition in which a higher degree of palliation is possible. The object of palliative treatment is to hold the growth in check, decreasing the symptoms and increasing the patient's general condition. When possible these results should be obtained without an untoward reaction. The group which is considered unsuitable for interstitial irradiation is comprised of patients usually in poor physical condition, and those with very large and deeply infected tumors. Implantation of gold seeds even in small dosages in a highly infected tumor is often followed by a reaction from which the patient may never completely recover. Over-radiation in these unsuitable cases may result in a slight prolongation of life, but the discomfort produced and the increased symptoms which may follow the implantation for a considerable period of time seldom compensate for the slight extension of life. Much of the adverse opinion of radiation therapy in rectal cancer has been created by intensive treatment of unsuitable cases.

There are a fair number of inoperable cases that are benefited by interstitial irradiation. The first class to be considered are those in which only small dosages are required. These patients are in fair physical condition. Their tumor is large, but the degree of infection is comparatively mild. Radon seeds are used under these circumstances to supplement the sublethal dosage supplied by external applications. The strength of seed varies from .75 to 1.50 millicuries, and the total dosage inserted at one time is seldom more than 20 millicuries. These small applications are often repeated as the initial dosage is not sufficient to influence the whole lesion. By repeating both the external and interstitial applications it is not unusual to carry these patients along for an interval of one or two years. Eventually, however, the tumor becomes badly infected and further interstitial irradiation is contraindicated.

The third class of inoperable cases consists of patients in fair physical condition who are able to withstand a moderate radium reaction, the result of which should be either a complete disappearance of the activity of the tumor, or a marked lessening of the symptoms over a much longer interval. The local lesion is large and usually a Grade I or Grade II malignancy. Radical surgery or attempt at removal in this type of case offers very little palliation. Too frequently radical surgery results in an operable fatality or early

recurrence which is harder to control than the original disease. If this group is untreated, or only a colostomy constructed, the period of comfort is comparatively short. Radon seeds appear to offer the greatest benefit of any of the present day methods of treatment. Seeds employed under these circumstances are of two or three millicuries each with a total dosage of 40 to 75 millicuries. Large amounts of radon are required because of the size of the tumor. An effort is being made to devitalize completely all the malignant cells of an inoperable case. There may be considerable postradiation reaction when this large dosage is employed, that may extend for several weeks. If cases are carefully selected one need not withhold treatment because of this reaction; for the ultimate result will well compensate for the period of discomfort. Colostomy is often required to relieve the obstruction produced by these large tumors. Moreover, the artificial opening greatly facilitates the implantation of the seeds, as it is employed as a means of approach to the upper limits of the tumor; the lower limits being treated by passing the proctoscope through the anal canal and lower rectum in the usual manner.

Gold seeds also have a place in the treatment of the operable rectal cancer group. We are all familiar with the frequency of early recurrences due to incomplete removal in the socalled operable case. In an attempt to improve this factor we have employed preoperative interstitial irradiation seven to 14 days prior to operation. The results in this advanced operable group warrant the continuation of this method as they have been much better than could be expected from surgery alone. The technic of preoperative therapy differs somewhat from that already described. Seeds from two to three millicuries are implanted into the outlying or infiltrating areas, the cancer cells serving as a holder for the radium. The total dosage delivered to these areas is in excess of that required for devitalization. In other words, an overdose is employed. The part of the tumor contained within the rectum proper need not be treated, as it is easily removed at the time of operation. The object in using radon in this manner is to devitalize only the outlying malignant cells, particularly those which may be left after a radical dissection. The short time between the application of radon and the operation does not permit the occurrence of any severe reaction even though massive dosage is employed. Moreover, the operation is not made any more difficult by preoperative irradiation unless an interval greater than a fortnight is allowed to elapse between procedures.

It is difficult to say what the additional percentage of clinical cures is afforded by the combined use of radiation therapy and surgery. However, clinical observation leads us to believe that a number of our cases operated upon owe their present satisfactory condition to this combined form of therapy.

There is a large field for postoperative radiation therapy in rectal cancer. It is fair to estimate that about one-half of the patients subjected to radical surgery die of cancer. Many deaths are associated with local recurrence.

If the local recurrence is accessible for interstitial irradiation and recognized early, a great deal of palliation, together with extension of life, can be provided these unfortunates. Gold seeds may be implanted at the time of operation if the surgeon considers that all malignant tissue has not been removed. If radon seeds are not available at this time they may be inserted during the convalescence as soon as the condition of the wound will permit. When the recurrence is discovered at a later date treatment should be given at once. Early recognition of a recurrence is almost as important as the early recognition of the primary lesion.

The previously considered indications for the use of gold seeds have all been in advanced or borderline operable cases. Gold seeds may be employed under more favorable circumstances, namely, in purely operable cases. By operable is meant a movable tumor of medium size in which the disease appears limited to the submucous and muscular coats without further involvement than the adjacent lymphatic nodes.

Operable cases for radiation therapy should be carefully selected. All operable cases should not be treated by this method. Tumors selected for this form of therapy must be so situated that seeds may be distributed accurately throughout the mass. In most instances they are located in the lower or mid rectum below the reflexion of the peritoneum. The general condition of the patient is such as to withstand a moderate radium reaction. The strain of such reaction is much less than that following radical surgery; therefore this may be the method of choice for operable tumors in patients unable to withstand a suitable operation. The majority of operable cases that have been treated by gold seeds have been in patients in rather poor physical condition, or in those who absolutely refused any form of surgery. Our results have led us to believe that the method may be extended to include a larger selected group. It is very gratifying when one is able to obtain a clinical cure of long standing and have the patient retain a normal and practically normal functioning terminal intestinal tract. Strong possibilities of clinical cures of operable tumors in good surgical risks should not be overlooked in our enthusiasm to use radiation therapy. Unless the tumor lends itself well to this method surgery should be the method of choice. With the proper setting in a disease that is localized, one need not hesitate to use this method, for we are employing an agent which, if adequately placed throughout the tumor mass, is capable of destroying all the cancer cells.

There is another type of case in which gold seeds are of great value; this is the precancerous or very early cancerous lesion. There may be a difference of opinion as to the malignant nature of such tumors. One pathologist may report a nonmalignant polyp, while another will consider the lesion an adenocarcinoma. Many of these early lesions are in elderly people in whom radical surgical procedure cannot be lightly considered. It has been our practice in recent years to remove these polyps or tumors with an electric snare and submit the whole removed mass for histologic study. The report of malignancy at the base places the lesion in a dangerous category. If there is any induration

of the mucosa after removal, this area is irradiated with gold seeds. The localization and the small area involved lends itself well to adequate interstitial irradiation by this method alone.

It is difficult to summarize the results from gold filtered radon seeds, as in most instances this form of therapy has been combined with external irradiation. A review of our active files shows 24 patients who were treated prior to 1933 to be clinically free of rectal cancer. In order to give a cross-section of our results, patients treated between 1926 and 1930, inclusive, have been reviewed. During this five-year period we were able to follow 238 patients treated by radiation therapy or radiation therapy and colostomy. Two hundred and thirteen of this number were advanced and suitable for only a moderate or minimal degree of palliation. Eighteen or about 8.5 per cent did not appear to be benefited by treatment. Forty or about 19 per cent received minimal palliation. A much greater degree of palliation was provided to the remaining 155 patients. The length of life in this advanced group was as follows: 183 lived over six months; 112 over 12 months; 65 over 18 months; 20 over 30 months; nine over three years; and one for four and two-third years. During this period there were 25 cases selected for heavy radiation therapy, the object being a clinical cure or a high degree of palliation. Fifteen of this number were considered operable, and ten inoperable. An artificial anus was constructed in 12 instances, while 13 patients were treated without any form of surgery. Thirteen of the 25 patients are now alive and clinically free of local disease. Of the 12 patients dead, three died of intercurrent conditions; and one from unknown causes. Of those dying unmistakably of their disease, one lived for 15 months; one for two years; three for three years; two for four and one-half years; and one for over five years. The results in this latter group compare favorably with those obtained from radical surgery alone. However, ten of these patients were considered inoperable, and many of the others were poor operative risks.

EXTERNAL IRRADIATION IN RECTAL CANCER

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EXTERNAL irradiation is an important procedure in the treatment of rectal carcinoma. This applies to all cases, and in all stages, although in a varying degree, according to the type of lesion, and also according to the other procedures to be followed in the care of the disease. Carcinoma of the rectum is rarely treated at this hospital by surgery alone, and is seldom subjected to external irradiation only, except for palliation in advanced stages. The combination of irradiation and surgery is usually required for the proper care of these patients. This discussion will be limited to external irradiation, simply mentioning the other procedures with which it may be combined.

External irradiation is used in the treatment of carcinoma of the rectum

in one of the following methods: (1) as an adjunct to surgery; (2) as a major procedure, surgery playing the minor part; (3) as the only procedure to be followed.

Surgery and External Irradiation.—In the operable cases external irradiation is usually the first step in the treatment, the exception being in that type of case which is in need of immediate colostomy. The reasons for irradiation preliminary to surgery are several. It is often our experience that even an operable case shows considerable toxicity with a consequent poor general condition of the patient. The external irradiation effects a general improvement and a sense of well being, as is manifested by increased appetite, gain in weight, and improved appearance. This type of therapy also causes a diminution of the infection, in the frequency of bowel movement, amount of mucus, and invariably arrests bleeding. These benefits also add to the general improvement of the patient. In no other type of neoplastic disease is there so prompt and decided improvement in the health of the patient. This improvement is often noted by the patient within a few days after the beginning of treatment. Another and important effect of this type of treatment is a decrease in the size of the tumor, which should make the surgery less difficult. This diminution in the size of the tumor occurs after the subsidence of the symptoms.

The tumor is exposed to irradiation through six to seven portals on the usual high voltage therapy unit, using 200 K.V., ½ Mm. cu. filtration at 70 cm. T.S.D. The six portal cycle consists of two anterior, two posterior and two lateral portals. The seventh portal is a perineal field when the tumor is in the lower rectum or anal region. The dose is usually 700 to 800 *r.* over each portal, or 500 *r.* with repetition. The dose is so calibrated that there will be no severe skin damage to delay the operation which is done two or three weeks following the last exposure to roentgen ray.

External Irradiation and Surgery.—In the inoperable group, surgery is indicated in obstructive lesions, the care of the tumor itself being delegated to external irradiation. This inoperable group may not be necessarily unfavorable. Because of the radiosensitivity of the tumor, it is possible to effect a complete regression by heavy external and interstitial irradiation. In a few instances in which the growth is rather extensive, but nevertheless localized to the pelvis, the greater dependence is put on the external irradiation following which the mass is excised as widely as possible, with implantation of radon in the residual tumor. The surgery here is of minor importance in the care of the lesion, the greatest dependence being put on the external irradiation, interstitial being used to complete the treatment.

With the same roentgen ray factors as in the previous group, the tumor is exposed through six or seven portals, depending on the location of the tumor. In this group we employ the divided dose method, using successive ports, thereby subjecting the tumor to irradiation daily, but exposing the skin to irradiation only the sixth or seventh day. The skin over each area is thereby allowed to recuperate over a period of six or seven days, while the tumor itself is being irradiated each day. The dosage is 500 *r.* per day to successive

ports until a total of 1,500 *r.* or 2,000 *r.* is given over each port. If the patient is unable to withstand this treatment, 400 *r.* are given daily to successive ports until a total of 1,600 *r.* is given to each. In the former instance, 18 to 21 days are utilized in delivering the dosage, while in the latter 24 to 28 days are needed.

This method of irradiation is especially applicable to those cases which are radiosensitive and offer a good prognosis. In nearly all instances it is necessary to implant the remaining mass with gold tubes of radon. In the more radiosensitive type of rectal carcinoma, the reduction of the mass is marked, and very little interstitial radon is required. This is a decided advantage, because this latter type of irradiation often produces a more or less severe systematic reaction, probably due to breakdown and infection of the tumor. Moreover, the pain following large doses of radon may be severe. Reduction of the size of the tumor permits a lesser dosage which is at the same time adequate. Expressing this in another way, as tumors are larger, we might say arithmetically, the interstitial dosage increases in almost geometric progression. It should be readily seen that this heavy external irradiation, with a marked reduction in the size of the tumor, offers a very decided advantage in the treatment of rectal cancer.

External Irradiation Alone.—At this hospital most of the cases applying for treatment are beyond that stage at which a cure can be anticipated because of the extent of the disease. Before institution of treatment, an estimate is made of the amount of palliation to be attained. In the more hopeful cases, the pelvis is irradiated in a manner similar to that group in which the greatest dependence is put on external irradiation and the residual carcinoma is cared for by gold seeds. Most of these patients show a marked improvement in their general condition and are able to carry on their regular routine for an indefinite period of time.

In the more advanced cases, the pelvis is irradiated with more intensive doses, thereby permitting a total amount of irradiation in lesser time and in fewer trips to the hospital. Practically all these patients show a marked general improvement in the general condition, though the degree of improvement depends on the sensitivity of the tumor, and also on the ability of the patient to withstand the treatment. It is readily understood that a debilitated patient, who must abbreviate his treatment time to conserve his strength which is taxed to the limit by frequent trips to the hospital, cannot be benefited to the same extent, as can the patient taking the full course of therapy.

It cannot be shown by statistics the amount of palliation that these patients receive, but it is obvious to anyone observing them that the symptoms are relieved, health improved, and life prolonged. The local effect of this palliative therapy may be noted by the lessened infection, decrease in size of the ulcerated area, and occasionally a fixed tumor may be found to have become more or less movable. With the general improvement, further irradiation may be given up to skin tolerance.

Since this is a discussion of external irradiation it might be of interest

to discuss briefly two of the very rare cases in which this type of irradiation caused the complete disappearance of the primary lesion. Quite obviously, these cases were of the very malignant type and therefore totally unsuitable for surgery. Even though the patients were not ultimately cured they received striking palliation. One man only 26 years old, with a bulky rectal tumor, received external roentgen ray to the anterior and posterior pelvis. The apparent complete regression lasted nearly four years, at which time there was reactivity of the disease, which was again controlled by radium through each lateral port of the pelvis. There was again some regression, but the patient died shortly afterward of liver metastases. The second patient was first seen in 1927 with a tumor which was 3.5 cm. in diameter, which did not occlude the bowel, but was almost completely fixed to the surrounding tissue. It was situated 8 cm. from the anal margin. He received two cycles of roentgen ray about the pelvis by the single dose method followed by radium element pack anteriorly and posteriorly. This man has remained free of any local evidence of disease. A few months ago he developed pulmonary metastases. Although these are not brilliant results, they are at least palliative results that could hardly be expected by any other method of treatment.

In this discussion roentgen radiation only has been mentioned as the method of external irradiation. This is so because this type of radiation is used in many clinics, whereas a pack with a sufficient quantity of radium for external irradiation is available in few institutions. It is my firm belief that radium is much more efficacious than roentgen ray for external irradiation; there is more marked regression of the tumor, and this regression should be more lasting. This latter statement may not be susceptible of proof, but it is a clinical impression gained by many observations.

The objection to external radium therapy is the time interval to deliver adequate dosage. In the operable cases, the operative procedure is too long delayed. In the group for palliative treatment, it is a great effort for a debilitated patient to make the required number of visits to the hospital. Hospitalization for the duration of the treatments is seldom possible. However, those cases with a favorable prognosis, and also those suitable for good palliation, should be treated by external radium therapy.

ANAL ANATOMY WITH REFERENCE TO THE WHITE LINE OF HILTON AND THE PECTEN OF STROUD

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IN 1863, Hilton[4] described a structure which bears his name as "A white line, which in the living subject any surgeon can recognize, shows the junction of the skin and the mucous membrane. That white line corresponds exactly to the lineal interval between the external and internal sphincter muscle. It is an important landmark, exact and truthful, so that it can be relied upon."

In 1896, the anatomist Stroud[7] described a region which he found in the anus of several species of animals and in man *post-mortem*, and which he designated as the "pecten." According to his description, the pecten is distinguished by the following features:

(1) It is bounded caudad (ectad) by the line of junction of the ectal and ental sphincters (Hilton's white line) and cephalad by the linea dentata.
(2) It has a smooth, even texture and a glossy, shining appearance. The color is intermediate between those of mucosa and skin.
(3) It has few or no openings of sweat-glands.
(4) It is moderately vascular.
(5) It is covered by a stratified epithelium which is richly supplied with nerve endings.

Miles[6] emphasized the significance of the pecten by describing the heavy deposit of fibrous tissue underlying it as the pathological result of inflammation, "pectenosis." In order to cure fissure-in-ano, it was necessary to cut this stenosing ring of fibrous tissue, or perform the operation of "pectenotomy." Abel[1] has recently reiterated the teachings of Miles.

Anderson,[2] after studying sections taken through one side of the anal canal, has recently stated: "(1) Hilton's line, as described by him, may be either the anorectal junction, or the pale ring in the anal canal, depending on interpretation. (2) Neither of these lines represents the depression between the external and internal sphincter muscles to any constant degree. (3) There is no constant relation between the anorectal junction and the underlying muscles."

From Martin's[5] writings, the following has been extracted: "The 'white line' of Hilton, just below the anorectal line, representing the condensation of tissue between the two sphincters, is much less elastic than any other portion of the anal canal. Some of the fibres from the mid-portion of the levator ani muscles find their insertion at this point."

It appears from the above excerpts that a certain amount of confusion

exists in the minds of anatomists and proctologists as to the two structures, Hilton's white line, and the pecten of Stroud. The cause of the confusion appears to be a lack of appreciation that Hilton's white line is a structure found in the living, whereas the pecten has been described from fixed and post-mortem specimens. Reflection on the part of the reader will immediately convince him that it is impossible for one to duplicate at post-mortem or by section conditions as they exist in life, since death and anæsthesia both cause relaxation of the sphincter muscles and distortion of their relationship to neighboring structures.

FIG. 1.—Sagittal section through perineum of a six months' premature fœtus. Eosin, hematoxylin stain.

A sagittal section through the entire perineal region (Fig. 1) post-mortem, shows the anus gaping, and the external sphincter, which in life is found caudal to the internal sphincter, lying lateral to it. This distortion does not become evident unless the section embraces both sides of the anal canal. The section further depicts three distinct types of epithelium: *i.e.*, the skin with its hair follicles and glands terminating where the uncornified epithelium begins, and the latter terminating at the anorectal or pectinate line where the mucous membrane begins. In the fœtus, these lines of division are sharply demarcated, but in the adult the levels of the lines of division may be greatly warped by existing or previously existing pathology. The uncornified skin is firmly fixed by and to subjacent fibrous tissue which begins at the termination of the muscularis mucosæ (Fig. 2 and Fig. 4) of the rectum and which is contributed toward largely by the fibrous terminations of the external longitudinal muscular coat of the bowel. The external longitudinal bowel terminations also penetrate the levator ani muscle, and some fibres pass between the various layers of the external anal sphincter to end in the cornified skin surrounding the anal opening. (Fig. 3.) Other fibres fix the internal anal sphincter by passing into it and through it in loops

and slings. The dense fibrous area beneath the uncornified epithelium of the anus surrounds the anus except at such points where the blood-vessels penetrate it to supply the sphincter region. This point was emphasized by the writer in a previous work.

The contention of Miles that the fibrous tissue deposition beneath the uncornified epithelium of the anus is the result of inflammation seems difficult to comprehend when one sees in the accompanying illustrations quite a deposition of fibrous tissue even before birth. One can readily appreciate, too, how at operation, if one were to cut the internal sphincter muscle, one might secure only bits of fibrous tissue for biopsy from the wound, since the spastic

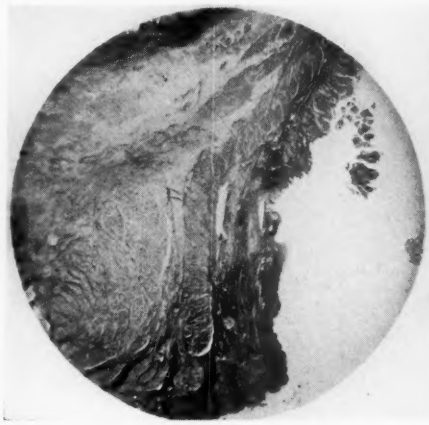

FIG. 2.—Section through one side of anal region in premature fœtus showing dense deposition of fibrous tissue beneath uncornified epithelial layer beginning at the termination of the muscularis mucosae. Van Giesen stain.

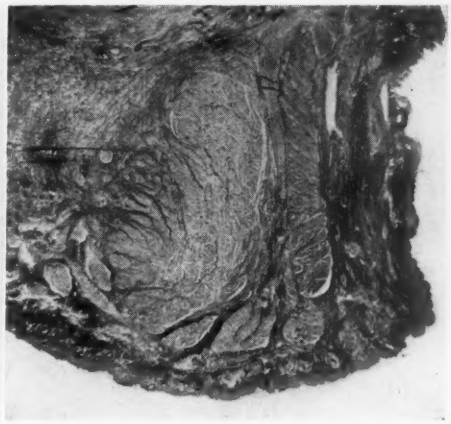

FIG. 3.—Section through one side of anal region in a premature fœtus showing disposition of the fibrous terminations of the external longitudinal muscle coat of the bowel. Van Giesen stain.

internal sphincter readily retracts when cut, leaving the abundance of fibrous tissue normally present readily available. On the other hand, in the narrowed ani of persons who have kept their stools liquid by the prolonged taking of saline cathartics, and in strictures due to other causes, there is undoubtedly a contracture accompanied by an increase in the fibrous tissue beneath the pecten.

The white line of Hilton, seen when the anal orifice is retracted, is in reality the pecten. It is the region of the uncornified epithelium and is essentially poorly vascularized. When the anus is retracted against the pull of the internal sphincter muscle, one can imagine how the blood might be forced out of this area and the appearance of a white line be produced. This white line appears to lie between the two sphincters, because it cannot be drawn down beyond the external sphincter muscle. In the living, when both sphincter muscles are contracted, it probably does lie pretty well between the two muscles, but when relaxed, as shown in the accompanying illustrations, the area ascends farther into the anal canal.

This region is of great significance clinically because it marks the divide

over which prolapsing masses of anal or rectal mucosa fall through the sphincter region. Immediately above this line lies the annulus hæmorrhoidalis where internal hæmorrhoids develop and caudal to the line is the site where external hæmorrhoids develop. The anorectal line may be carried out of position as may the line of junction of cornified and uncornified skin by pathological processes, but the pecten of Stroud or the white line of Hilton

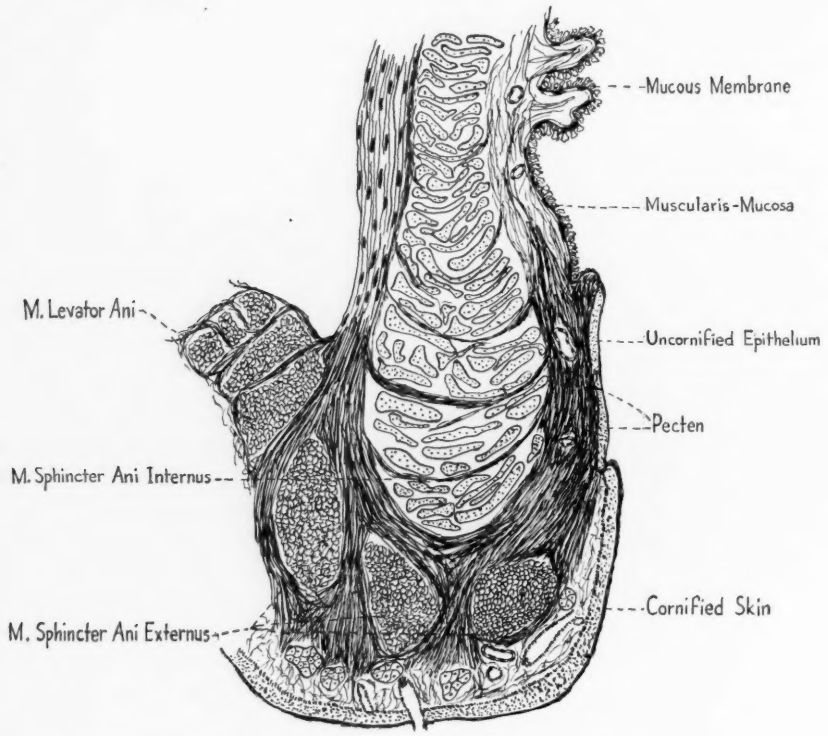

FIG. 4.—Drawing from a section of the anus showing the disposition of the fibrous terminations of the external longitudinal muscle coat of the bowel.

is a true landmark. The only point upon which Hilton was inaccurate was in his description of his line as the junction of the skin and mucous membrane.

SUMMARY

In the living, the white line of Hilton is a definite anatomical landmark. Post-mortem anatomical relationship of anal structures differs from that found in the living because of relaxation of the sphincter muscles. The heavy area of fibrous tissue deposition beneath the uncornified epithelium of the anus begins at the termination of the muscularis mucosæ and receives contributions from the fibrous terminations of the external longitudinal muscle coat of the bowel and probably also from the levator ani muscles. The white line of Hilton and the pecten of Stroud are probably identical.

REFERENCES

[1] Abel, A. Lawrence: The Pecten Band: Pectenosis and Pectenotomy. Lancet, vol. 1, p. 714, April 2, 1932.

[2] Anderson, James Kerr: Anal Anatomy, with Particular Reference to the Anorectal Junction. Journal-Lancet, vol. 53, p. 83, February 15, 1933.

[3] Hiller, Robert I.: The Anal Sphincter and the Pathogenesis of Anal Fissure and Fistula. Surg., Gynec., and Obstet., vol. 52, p. 921, 1931.

[4] Hilton, John: Rest and Pain, p. 289. G. Bell & Sons Ltd., London, 1930.

[5] Martin, Collier F.: Ano-rectal Fistula. Amer. Jour. of Surg., vol. 39, p. 302, December, 1925.

[6] Miles, W. Ernest: Observations upon Internal Piles. Surg., Gynec., and Obstet., vol. 19, p. 497, 1919.

[7] Stroud, Bert B.: The Anatomy of the Anus. ANNALS OF SURGERY, vol. 24, p. 1, 1896.

FRACTURE OF THE ANTERIOR INFERIOR SPINE OF THE ILEUM

SPRINTER'S FRACTURE

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THE widespread development of athletics makes it desirable that certain injuries which occasionally occur in athletic activities be more generally known. In preparatory school boys such injuries are particularly likely to occur because of the non-union of various epiphyses in the age group to which they belong. Fracture of the anterior spines of the ileum would appear to be a very uncommon condition if one were to judge either by the scant mention it receives in the few text-books on fractures in which it is mentioned or by the scarcity of reports in the literature; there have been very few cases of this disorder reported in this country. The two cases reported here, however, occurred in a small community within seven months time.

Forty-eight cases of fracture of either the superior or inferior anterior iliac spine have been reported: Carp[1] in 1924 collected twenty-one cases; in 1933 Christopher[2] collected twenty-four more and recently Rothbart[6] has reported three more cases. The majority of these injuries occurred during rapid running (hence the term "sprinter's fracture"), but others have developed following kicking, turning backward while running, jumping, or slipping. Practically all the cases occurred in males from fifteen to twenty-three years of age, the latter being the age at which these epiphyses unite. The anterior-superior spine is more frequently fractured than the inferior; however, in the two cases reported here and in those of Pezcoller,[5] Rothbart[6] and Corlette,[3] the anterior inferior spine was involved.

Christopher[2] believes that one factor in producing this condition may be the tension exerted by inelastic muscles at the point of their attachment, and he advises that runners be well warmed up before participating in sprints.

The fracture of one of the anterior iliac spines will be suggested by sudden pain at the hip occurring during such an activity as running, with a subsequent development of pain in the inguinal region, pain and difficulty on attempting to flex the thigh, and pain over the affected spine. Symptoms of a mild vasomotor disturbance such as syncope or vomiting may occur. In the presence of fracture of the anterior superior spine the fragment may be found to be movable under the examining finger.

CASE I.—P. E., a sixteen-year-old schoolboy, was entered in a 220-yard dash May 4, 1933. Previous to that day he had never experienced any difficulty in running. He was well warmed up before the race and had run about 150 yards when he suddenly experienced sharp pain at his right hip, stumbled, and faltered to the finish. He then limped off the track, dropped onto the grass, vomited, and was unable to arise. On examination at the hospital, there was tenderness on palpation at the right groin and the patient was unable to flex his thigh. Roentgen examination showed a separation

of the anterior inferior spine of the right ileum (Fig. 1). The patient was put to bed with his knee flexed for six weeks, and was then allowed up and about on crutches for two weeks. At the end of another six weeks the function of that leg was perfectly normal.

CASE II.—D. H., a seventeen-year-old schoolboy, had occasionally noticed pain at his

FIG. 1.—Roentgenogram taken of Case I directly after his injury.

FIG. 2.—Roentgenogram taken of Case II directly after his injury.

right hip during the autumn track practice periods, but had always stopped running at the onset of pain and obtained relief within a few minutes. November 30, following an adequate warming-up period, he participated in a relay race. The start in this race was from the conventional upright position, with trunk rotated and right leg posterior. About fifty yards after starting he felt extreme pain at the right hip which hampered his stride greatly, but he was able to finish the race. At the finish he was obviously in great discomfort, and felt very faint. On examination there was exquisite tenderness at the right groin; the anterior superior spine was not tender or movable; the patient was unable to flex the thigh. A roentgenogram (Fig. 2) showed a fracture of the anterior inferior spine of the right ileum. The patient was put to bed with the knee flexed, and two days later a plaster spica was applied. The case was removed after four weeks and crutches were used for the next two weeks. Special exercises were given which rapidly overcame the atrophy of the thigh muscles. An X-ray examination (Fig. 3) January 12, 1934, showed extensive callus formation, and within ten weeks following the injury the function of the leg was again apparently perfectly normal.

FIG. 3.—Roentgenogram taken of Case II seven weeks after his injury occurred. The formation callus may be seen.

Comment.—Two cases of fracture of the anterior inferior spine of the ileum are reported. Both of these injuries occurred during foot races and in both instances the boys were well warmed up before the start of the race. The symptoms and signs were very similar in these two cases: pain at the right groin, inability to flex the thigh and mild vasomotor disturbance. The

roentgenograms, which are reproduced, show the separation of the anterior inferior spine. It has been suggested that a cold muscle may be responsible for the extra strain at the epiphysis and may cause a fracture, but although that is no doubt occasionally an etiologic factor, the injury occurred in these two cases in well warmed muscles. The frequency with which this type of injury has occurred in runners suggests that one factor may be the over-development of the muscles attached to the epiphysis, which before its complete union is incapable of withstanding the strain put upon it. Eliason[4] believes that this fracture is frequently caused by a sudden forcible contraction of the rectus femoris muscle, such as occurs in sprinters at the start of a race. It may be significant that in a case reported by Christopher[2] and in Case II of this report, mention is made of the fact that for some weeks prior to their accident both boys had noted pain in the region at which the fracture subsequently occurred; the question might be raised as to whether a mild epiphysitis may have been present for some time prior to the accident and played a part in the subsequent fracture.

The histories of those two injuries suggests that many a "pulled tendon" occurring under similar circumstances in boys in this age group may be, in reality, an avulsion at an epiphysis. At any event, roentgenograms in such instances would be of interest. The principle of treatment employed is the relaxation of the flexors of the thigh for a period sufficiently long to allow union and healing of the separated epiphysis; this is best achieved by the maintenance of the knee in a position of ninety degree flexion by the proper adjustment of a Gatch bed or by pillows, methods which will prove more satisfactory than treatment in a plaster case.

SUMMARY.—(1) Two cases of fracture of anterior inferior spine of the ileum together with the signs and symptoms of this disorder are reported.

(2) The suggestion is made that this type of fracture is not as uncommon as the scarcity of reports would indicate.

(3) A few of the factors having an etiologic relationship to this disorder are mentioned.

(4) The desirability of using the roentgenogram in similar cases, rather than assuming that the injury in only a "pulled tendon," is suggested.

REFERENCES

[1] Carp, L.: ANNALS OF SURGERY, vol. 79, p. 551, 1924.
[2] Christopher, F.: J.A.M.A., vol. 100, p. 113, 1933.
[3] Corlette, C. E.: Med. Jour. Australia, vol. 2, p. 682, 1927.
[4] Eliason, E. L.: Nelson's Loose-Leaf Living Surgery, vol. 3, p. 342; New York, Thomas Nelson & Sons, 1927.
[5] Pezcoller, A.: Clin. chir., vol. 34, p. 249, 1931.
[6] Rothbart, L.: Zentralbl. f. Chir., vol. 59, p. 781, 1932.

MANAGEMENT OF DEPRESSED FRACTURES OF THE SKULL AND OLD SKULL DEFECTS

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CRANIAL injuries are frequent in these days of high speed and reckless driving. It is true that the extent of associated brain damage is the most important criterion in the prognosis of a given case of head injury. However, in not a small number, the deformities and defects in portions of the cranium not covered with hair constitute an important problem. A surgeon should always be cognizant of the influence of such deformities on the personality of the individual and his mental state, for in some they can easily cause mental problems of serious import. A discussion of the management of old skull defects is not complete without a consideration of the proper management of depressed fractures of the skull, for the latter are practically always the forerunners of skull defects. If depressed fractures are treated with careful planning before operation, plastic repair at a later date would not be necessary in the majority. Therefore, in this paper a critical discussion of the operative treatment of acute depressed fractures of the skull will precede the consideration of the management of old defects.

MANAGEMENT OF ACUTE DEPRESSIONS

In the management of an acute case of simple or compound depressed fracture we should not only think of the treatment necessary to save the patient's life but we should also be conscious of the necessity to hold to a minimum the resultant defects and deformities in portions of the cranium, which would alter the appearance of the individual. It is not the contention to have necessary and careful work suffer at the expense of final good appearance. It is true that in some cases it is perfectly proper to treat the patient without regard to resultant change in physiognomy. However, there are sufficient number of cases which can be treated in the acute stage in a way to insure not only a good esthetic result but also to obviate later operative work to improve the patient's appearance.

In a series previously reported,[6] about 40 per cent of the simple and compound depressed fractures occurred in the anterior third of the skull. These ranged from very severe fractures destroying the frontal sinuses or the superior orbital rim or both to those of the puncture variety where only a piece of bone one inch or less in diameter was depressed. From the standpoint of clinical manifestations the cases ranged from practically moribund to asymptomatic types.

In the management of acute cases of depression four general plans of attack are at our disposal. These have been described repeatedly in various

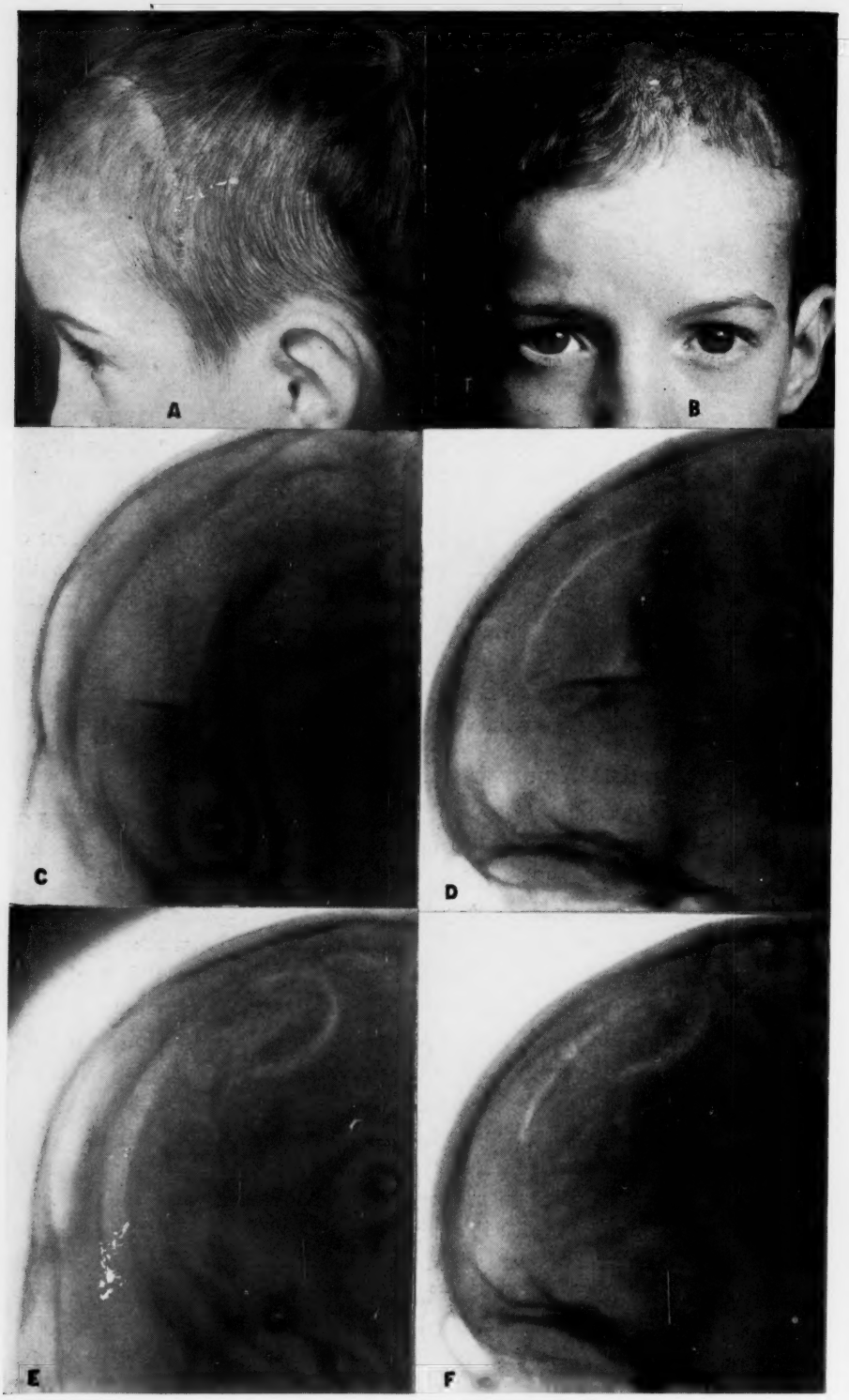

FIG. 1.—Case of compound depressed skull fracture, left frontal region. Through a horseshoe incision the area of depression was exposed. A large trephine removed a button of bone including a portion of normal skull. The remainder of the depression was then elevated and after readjusting the depressed portion of the removed button of bone the latter was replaced. The photographs show a normal contour of the forehead. This depression was about two inches in diameter and extended well into the forehead. A marked deformity would have ensued if the area of depression had merely been rongeured away.

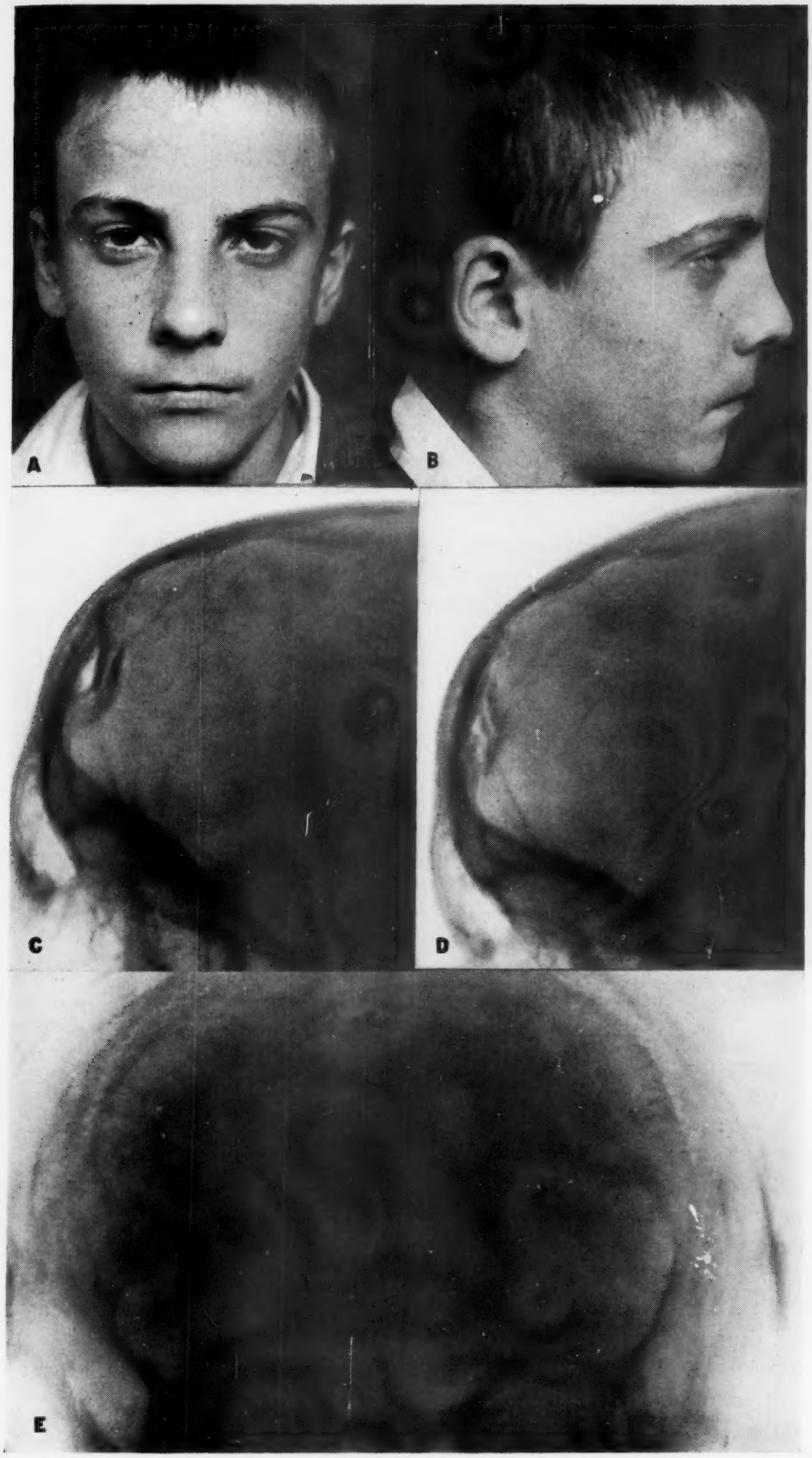

FIG. 2.—Case of compound depression of the right forehead. The area of depression was less than two inches in diameter. The entire area was trephined and following readjustment of the depression in the button of bone, the latter was replaced. Here again a bad deformity would have ensued if the depression had merely been rongeured away. The photographs show the final result.

contributions but I feel that it is worth while to give them a critical consideration.

First, Removal of the Area of Depression.—Unfortunately, this is the most common method used. The area of depression is rongeured away without any consideration given to subsequent deformities and defects in the skull. In the portion of the skull covered with hair such procedure is not of serious consequence but in the forehead region such destruction of contour will necessitate a further operative procedure for esthetic purposes or will leave

FIG. 3.—Demonstrating the method of obtaining the transplant from the outer table of the skull. After freshening the border of the defect with the same trephine, a good fitting is obtained when the transplant is placed in the area of the defect. This method can be used in cases with small defects. In the fresh case, if the bone in the region of the depression is missing or contaminated beyond use such a repair may be obtained immediately, particularly when the patient is asymptomatic or relatively so.

the patient with a permanent disfiguring defect. A certain amount of forethought and careful planning before operation can in many instances obviate this possibility.

Second, Elevation of Depression by Means of a Bone Elevator Passed under the Area of Depression Through a Small Opening to One Side of the Defect.—The method of approach has its best application in children. The so-called "derby hat" type of depression can be thus treated with excellent results. However, in the adult the inner table of the skull is so often shattered and depressed without an associated depression of the outer table of equal severity, that working blindly through a small opening one can easily cause damage to the dura, diploic bleeding and at times elevation of the outer table

with little or no elevation of portions of the inner table. Furthermore, this method does not allow the operator to inspect the dura. I use this method in children and also in some adults after careful examination of the radiographs. It is inferior to the next method of approach.

Third, Mass Removal of the Area of Depression Including a Strip of Normal Bone Surrounding It. After Readjusting the Depression Replacement of Bone Flap.—This method is the most satisfactory for it enables the operator to get a good esthetic result, it allows inspection of the dura and if necessary incision of the latter and inspection of intradural contents. Two methods for mass removal are: First, osteoplastic flap method, namely, making several openings in the skull surrounding the area of depression and sawing off the intervening skull with a Gigli saw. Second, the trephine method, namely, using a trephine one and one-half to two inches in diameter and removing the entire area of depression. If the depression is larger than the circumference of the trephine used, as may frequently be the case, the button of bone removed should include a portion of normal skull. This is followed by careful elevation of the remainder of the depression and replacement of the button of bone. I prefer the trephine method as it causes less shock, less bleeding and takes much less time (Figs. 1 and 2).

Fourth, If the Area of Depression Is Beyond Repair or if Pieces of Bone Have to Be Discarded Because of Contamination, the Defect May Be Treated by Transplant from the Outer Layer of the Skull.—The transplantation of bone becomes very simple if the size of the defect is within the limits of the circumference of the trephine used. In some cases because of the patient's condition one may not be able to treat the defect in the first operation, if so in the absence of infection plastic repair may be obtained within a few weeks. In cases with little or no clinical evidence of associated brain damage plastic repair at the first operation is not rash surgery (Fig. 3).

It is true that in some cases it is impossible to do all one desires, for instance, in compound depressions involving the frontal sinus region and the roof of the orbit it is important primarily to fight infection. Therefore, in such cases all foreign particles and pieces of contaminated free bone are removed. If there is a laceration of the dura, the latter is well exposed and repaired if possible. It is usually necessary to pack the wound. After such operative procedure extensive defects in the forehead are not uncommon. In such cases further work to repair the defect is necessary.

In this clinic it is the policy not to disturb slight simple depressions with no symptoms. Particularly is this true in the forehead area and the region of the frontal sinuses. Of course compound fractures depressed or otherwise are carefully débrided and cleansed in the usual manner. The work of Naffziger and Glaser[11] on experimental depressions is interesting and certainly is frequently proven to be correct on clinical grounds. They state that brain injury obtains at the time of the blow and that the presence of a slight depression *per se* is not productive of brain dysfunction. This is certainly true in the majority of cases and speaks favorably for conservative treatment in the

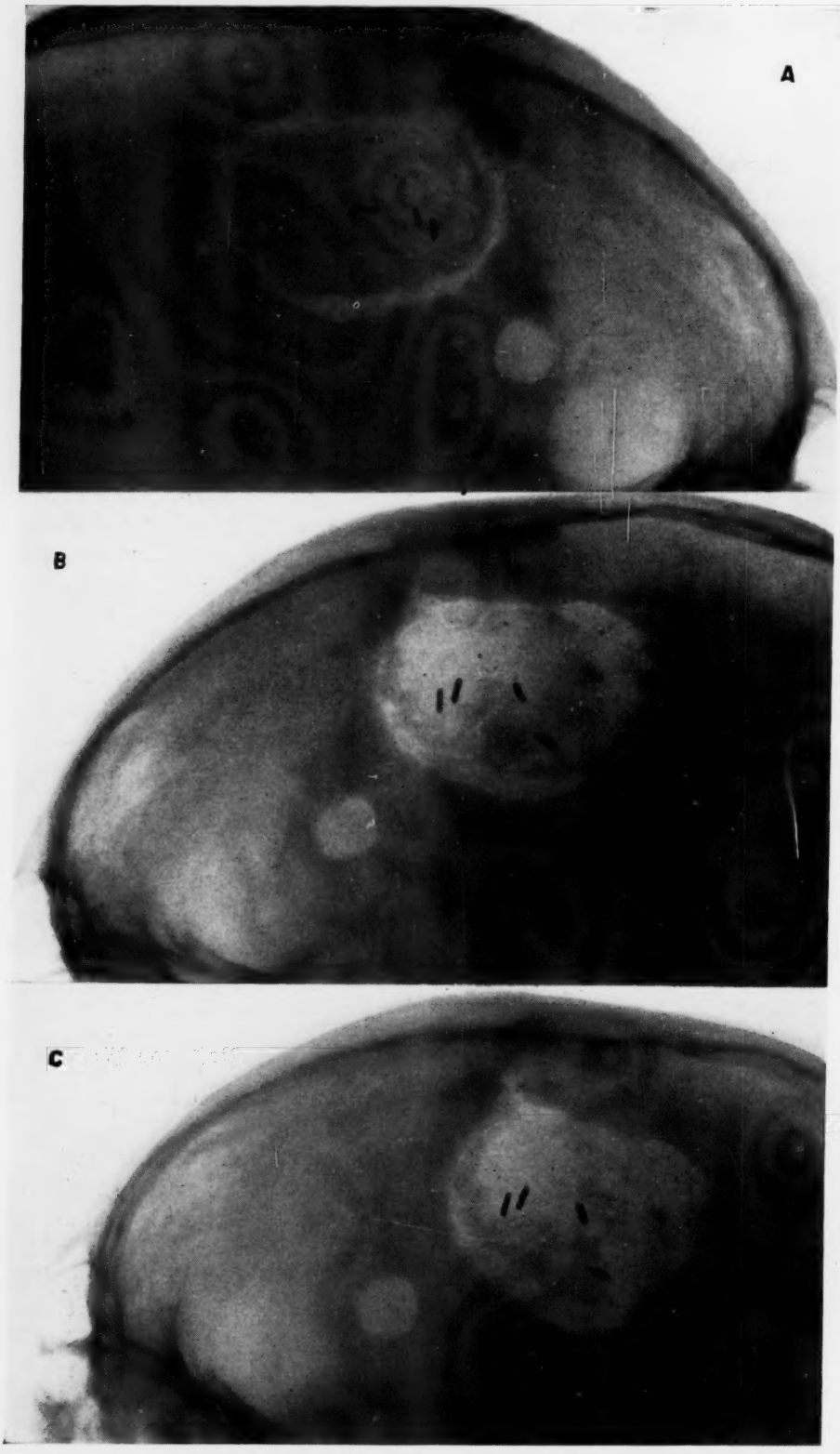

FIG. 4.—Demonstrating the gradual disappearance of autopsy skull bone used for transplantation purposes. In (A) there is beginning decalcification three months after repair. In (B) there is more evident decalcification nine months after repair. In (C) there is practically complete disappearance of the transplant 15 months after repair. There was no infection or sequestration in this case.

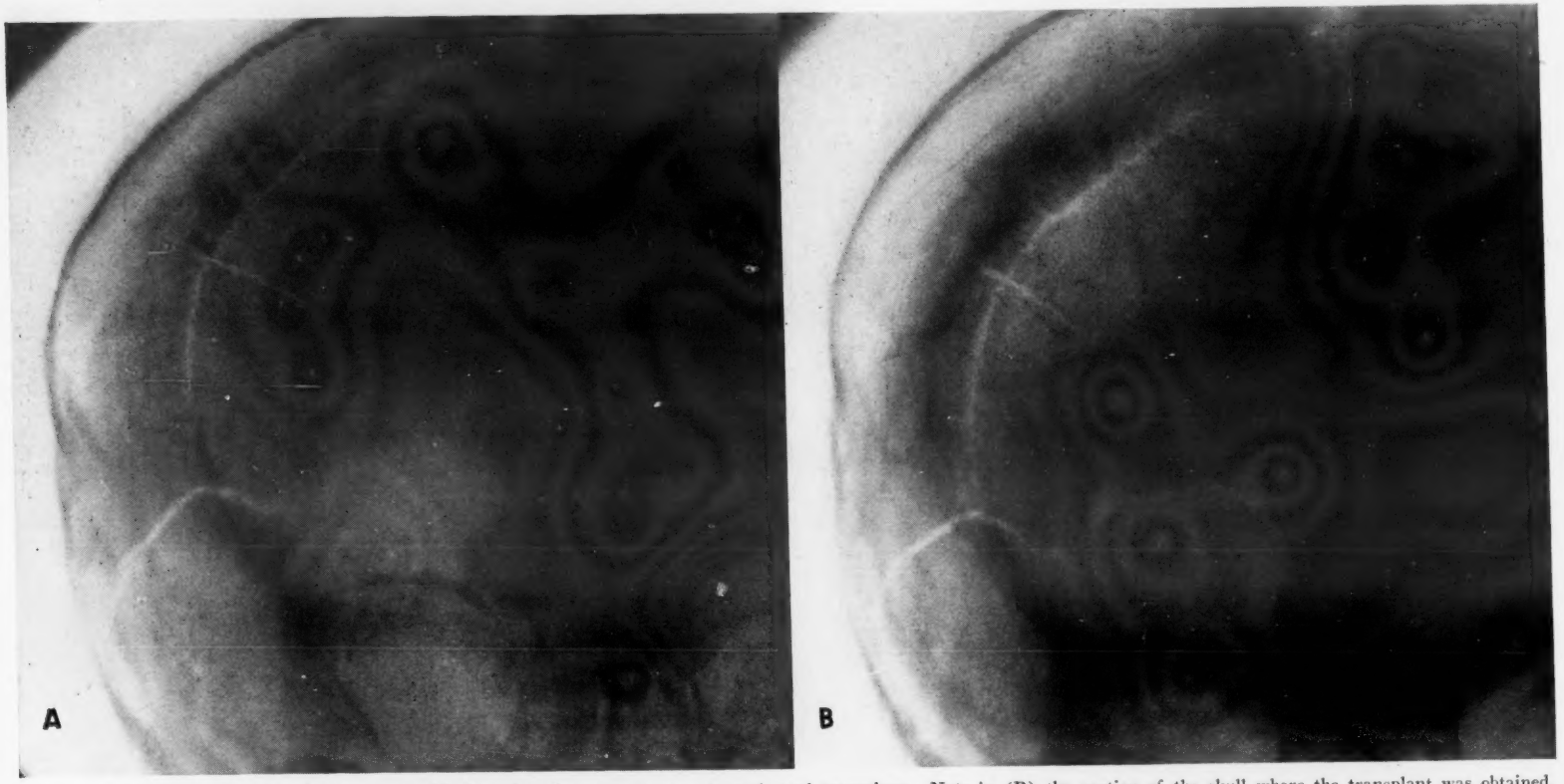

FIG. 5.—Illustrates a repair of the supra-orbital region by autogenous osteoperiosteal transplant. Note in (B) the portion of the skull where the transplant was obtained. There is good preservation of the inner table of the skull.

FIG. 6.—Showing repair of a midfrontal defect with autogenous osteoperiosteal transplant. The anteroposterior and lateral views of the patient before operation show a disfiguring defect. The anteroposterior and lateral views of this patient after operation were obtained 14 months after repair. This patient's defect was caused by compound fracture of the skull involving both frontal sinuses and exposing both frontal lobes.

FIG. 7.—Case of compound fracture involving the left forehead, supra-orbital rim and frontal sinus. He developed a frontal lobe abscess which was drained. After three months repair of the forehead was obtained by using autogenous osteoperiosteal transplant. (B) shows bony union in the region of the defect. Photographs show condition and final result after operation. Last photographs taken 16 months after repair. Patient shows some external strabismus. Before operation there were marked protrusions of the eyeball on the left but this has practically completely disappeared since repair.

FIG. 7.—Case of com[illegible]nd fracture involving the left forehead, supra-orbital rim and frontal sinus. He developed a frontal lobe abscess which was drained. After three months repair of the forehead was obtained by using autogenous osteoperiosteal transplant. (B) shows bony union in the region of the defect. Photographs show condition and appearance before operation and final result after operation. Last photographs taken 16 months after repair. Patient shows some external strabismus. Before operation there were marked pulsations of the eyeball on the left but this has practically completely disappeared since repair.

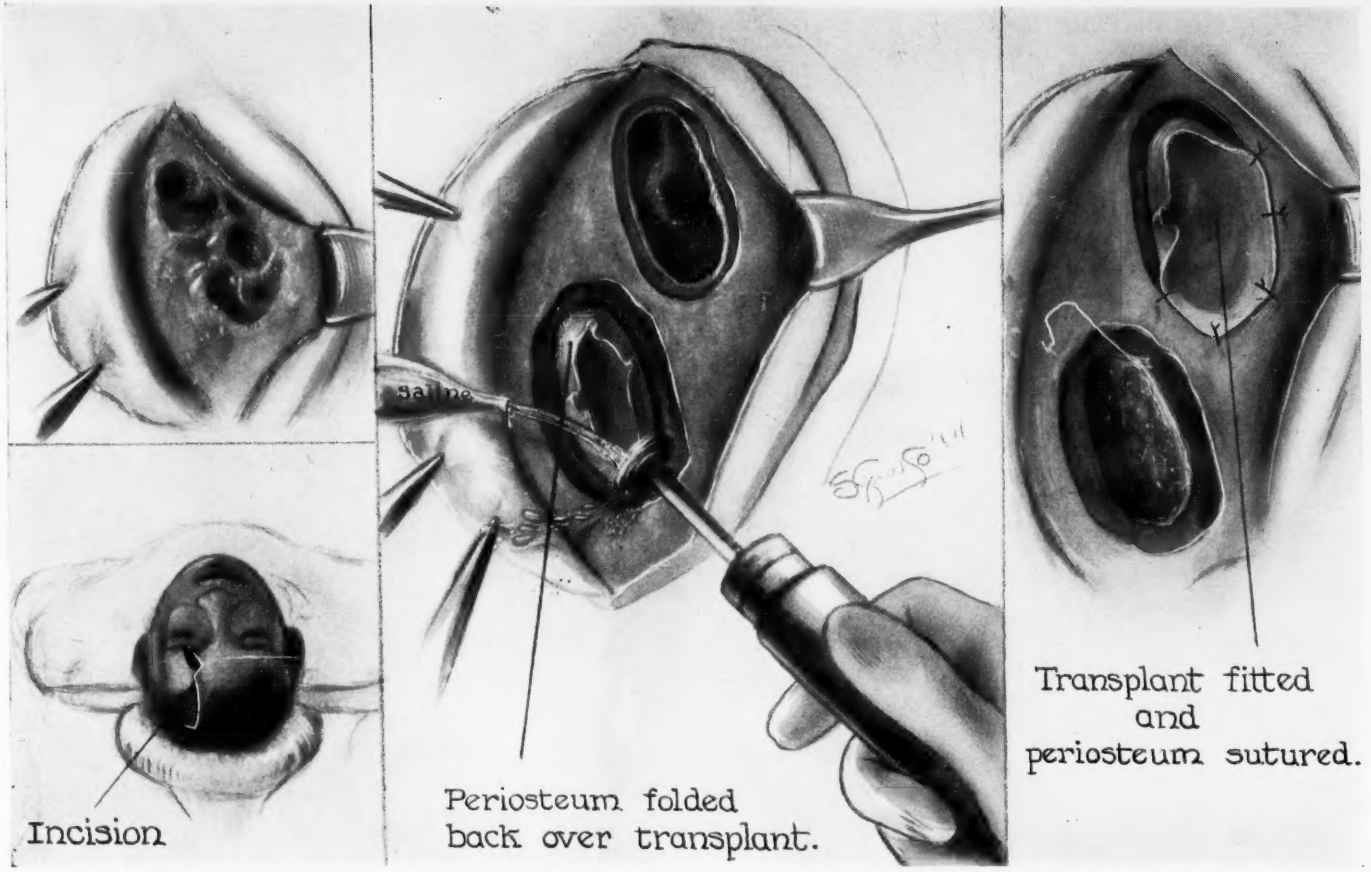

FIG. 8.—Shows repair of a defect in the forehead. The use of a rotary saw we feel is very important in the obtaining of the transplant. By cutting down to the diploe with a saw the transplant obtained is much firmer and more solid. There is less likelihood of a deeper penetration with a chisel if the rotary saw is used first.

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case of slight depressions. In a previous paper it has been shown that simple slight depressions and simple fractures in the region of the frontal sinus do well with conservative treatment. Where there is spinal fluid rhinorrhea associated with fractures in the frontal sinus region it is good surgery after careful examination of the radiograms to expose the tear in the dura and repair it if possible, or pack it against the brain as suggested by Peet.[13]

MANAGEMENT OF OLD DEFECTS OF THE SKULL

The indications for repair of old defects of the skull are first, better esthetic results and second, alleviation of symptoms of headache and dizziness in cases with large defects. The various authors consulted also list traumatic epilepsy as one of the conditions cured by repair of old defects, although I doubt the efficacy of this mode of treatment, for permanent cure, in convulsive sequelae of head injury. A great deal of work on repair of old defects has been reported in the past thirty years but the greatest advance has been made with the large amount of material during the Great War and since that time.

Various transplants have been used. Inanimate objects, such as, silver plate, aluminum plate, vulcanite, *etc.*, have been used (Mitchell,[10] Elsberg[4]). Heterogeneous transplants have been advocated by using flat bones from sheep, oxen, birds, *etc.* (Babcock,[1] Pankratiev[12]). The use of bones from human autopsy material has been advanced by several investigators (Westerman, Pankratiev). Transplants from the body of the same individual have been obtained from tibia, rib, scapula, iliac bone and outer plate of the skull (Breniger,[3] Rhodes,[16] McWilliams,[9] Jones,[7] Primrose,[14] Bagley[2]). Autogenous osteoperiosteal transplants from the outer plate of the skull were advocated as early as 1905 by Keen.[8] Since then a great deal has been learned about this method of approach (Frazier,[5] Primose, Reed,[16] Peet[13]). I feel that of various material used, autogenous osteoperiosteal transplants work best. In the present material I employed osteoperiosteal transplants in eight cases, dead boiled skull from human autopsy material in two cases, and rib in one case. Dead bone (Fig. 4) and rib transplants disappeared within 18 months after application. The osteoperiosteal transplant from patient's own skull, however, seemed to carry on and in four cases there is evident bony union as evidenced by radiography.

Briefly, the operative technic is as follows (Fig. 8). Through an appropriate incision the defect is fully exposed. The contour is freshened by rongeuring away a thin strip of bone. The periosteal lining along the defect is carefully saved. Either through extension of the same incision—or, if not practical, through a separate horseshoe flap—a portion of the skull is exposed, preferably the parietal bone near the midline. Care is taken not to disturb the pericranium when the bone is exposed. The outline of the defect is placed on the exposed bone, the periosteum is incised along the outline or about a centimeter beyond it. The periosteum is then puckered toward the center of the bone to be removed. With a rotary saw the bone is cut down to the diploe along the outline of the transplant needed. With a sharp chisel the transplant

is then removed, consisting of the outer table only. The inner plate bleeding may be stopped with bone wax. The transplant is then placed in the defect after any necessary adjustments are made for better fitting. The periosteum of the transplant is then sutured to the periosteum along the defect.

If the defect is sufficiently small a trephine of the proper size may be used, both to freshen the inner margin of the defect and to obtain the transplant from the outer table of the skull. I use the free graft although for defects in portions of the skull covered with hair the flap graft may be used with advantage. The latter may be found to be more successful than the free graft. In the region of the forehead, the flap method cannot be used advantageously because the bone is usually thinner in this region and there is less likelihood for a smooth clean result from the esthetic standpoint.

The fate of transplants from the outer table of the skull can be followed fairly accurately with radiograms (Figs. 5, 6, and 7). It is my impression that in the successful case the transplant remains viable throughout, obtaining its nourishment from the surrounding vascular tissue. This impression is based on both radiographic findings and reopening of some of the cases for further plastic repair. In the latter the transplanted bone was found to bleed as one would expect it in a living bone. That the transplant behaves like a host for osteogenesis such as described for long bones does not seem to be the case in transplants of the skull.

SUMMARY AND CONCLUSIONS

Careful planning before operation in cases of acute depressed fracture may frequently solve the problem of allowing the minimum postoperative deformity. As has been brought out in the text, mass removal of the area of depression and replacement of the flap following readjustment of the depressed pieces gives excellent esthetic results. Such a procedure is particularly commendable when the patient is asymptomatic or shows few clinical evidences of brain injury. In such a case the debatable question of decompression does not arise.

In old defects and in those acute cases which cannot be treated without causing deformities of the skull, autogenous osteoperiosteal transplants obtained from the outer table of the patient's own skull give excellent results. It is true that occasionally spontaneous osteogenesis does obtain even in extensive defects of the skull. Particularly is this true in children; in adults it is rather unusual. However, if spontaneous osteogenesis does take place, the usual convex contour of the skull is lost and in portions not covered with hair such spontaneous repair of the skull is as disfiguring as no repair at all. It is, therefore, perfectly proper to repair such cases as soon as possible and not lose time waiting for spontaneous repair to occur.

REFERENCES

[1] Babcock, W. W.: Soup Bone Implant for the Correction of Defects of the Skull and Face. J.A.M.A., vol. 69, p. 352, 1917.

[2] Bagley, C.: Gunshot Wounds of the Brain and Retained Missiles. Surg., Gynec., and Obstet., vol. 31, p. 448, 1920.

[3] Breniger, A. G.: Total Bone Grafts into Skull Defects. ANNALS OF SURGERY, vol. 64, p. 516, 1916.

[4] Elsberg, C.: Plate for Skull Defects. ANNALS OF SURGERY, vol. 47, 1908.

[5] Frazier, C. H., and Ingham, S. D.: Review of the Effects of Gunshot Wounds of the Head. Tran. Am. Neurol. Assn., June 17, 1919.

[6] Gurdjian, E. S.: Studies on Acute Cranial and Intracranial Injuries. ANNALS OF SURGERY, vol. 97, p. 327, 1933.

[7] Jones, B. L.: Bone Transplantation from Scapula. ANNALS OF SURGERY, vol. 66, p. 160, 1917.

[8] Keen, W. W.: Filling Defects in the Skull by Bone Chips from the Outer Table of Neighboring Bone. ANNALS OF SURGERY, vol. 42, p. 296, 1905.

[9] McWilliams, C. A.: Bone Grafting: Collective Review. Surg., Gynec., and Obstet., vol. 22, 1916.

[10] Mitchell, A. B.: Repair of Injuries to the Skull by Perforated Plates. British Jour. Surg., vol. 5, p. 40, 1917.

[11] Naffziger, H. C., and Glaser, M. A.: An Experimental Study of the Effects of Depressed Fracture of the Skull. Surg., Gynec., and Obstet., vol. 51, p. 17, 1930.

[12] Pankratiev, B. E.: Dead Bone Grafts to Repair Skull Defects. ANNALS OF SURGERY, vol. 97, p. 321, 1933.

[13] Peet, M. M.: Symptoms, Diagnosis and Treatment of Acute Cranial and Intracranial Injuries. Indust. Doctor, vol. 5, No. 7, 1927.

[14] Primrose, A.: Cranioplasty. The Value of a Graft of Bone, Cartilage or Fascia in the Closure of Cranial Defects Caused by Wounds in War. ANNALS OF SURGERY, vol. 70, p. 1, 1919.

[15] Reed, J. V.: Repair of Cranial Defects. Am. Jour. Surg., vol. 18, p. 285, 1932.

[16] Rhodes, R. L.: The Treatment of Cranial Defects by Bone Grafting. Surg., Gynec., and Obstet., vol. 19, p. 546, 1914.

FRACTURES OF THE BODIES OF THE VERTEBRAE *

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A CONSIDERATION of fractures of the bodies of the vertebrae must include their anatomic structure, blood supply and development. Investigations on these subjects have been going on from various angles. Probably the most authoritative work has been Schmorl's,[12] but in this country Eben Carey, W. A. Evans,[6] A. G. Davis,[4] John Dunlop,[5] George Wagner and E. P. Pendergrass,[14] with R. W. Jones,[9] Böhler[2] and others in Europe, have simplified and rationalized treatment.

The blood supply and development of the vertebral bodies has been restudied both anatomically and roentgenologically by several investigators until it has become possible to recognize the so called epiphyseal plates on the transverse surfaces with their small notches in the anterior border of the body and the site of entrance of arteries and exit of veins near the center. The large venous sinusoids occupying more than a quarter of the volume of the corpus have also come to recognition in the roentgenogram and in clinical consideration.

Along with this information much has been learned about the intervertebral disks, their elasticity, structure, variation and changed appearance after various traumata or congenital misplacements. They are known to represent one-sixth to one-fifth of the length of the spinal column and their self-contained character without definite blood supply and their relatively perfect incompressibility, if unruptured, have assisted in the study of the mechanism of fractures of the body.

Daily study of roentgenograms of the spine in two axes brings out differences in details of the primary bone displacement in fracture and its effect on prognosis and treatment. The finely meshed cancellous bone of the vertebral body, weakened by unclosed epiphyses and venous sinusoids in adolescence and affected in later life by senile changes found in all bones of similar structure, is subject to injury by both direct and indirect violence, the latter most often.

A survey of the mechanics of compression fracture of the corpus consequently exposes the several elements that enter into the injury. These are:

(1) The arrangement and anatomy of the trabecular scaffolding of the bodies.

(2) The circulation to and situation of the venous sinusoids in the vertebral body.

(3) The direction of the lines of force of trauma from direct compression in the long axis and those of pure flexion and compression flexion combined with their effect on the corpus vertebrae.

* Read before the Western Surgical Association, St. Louis, Mo., December 8, 1934.

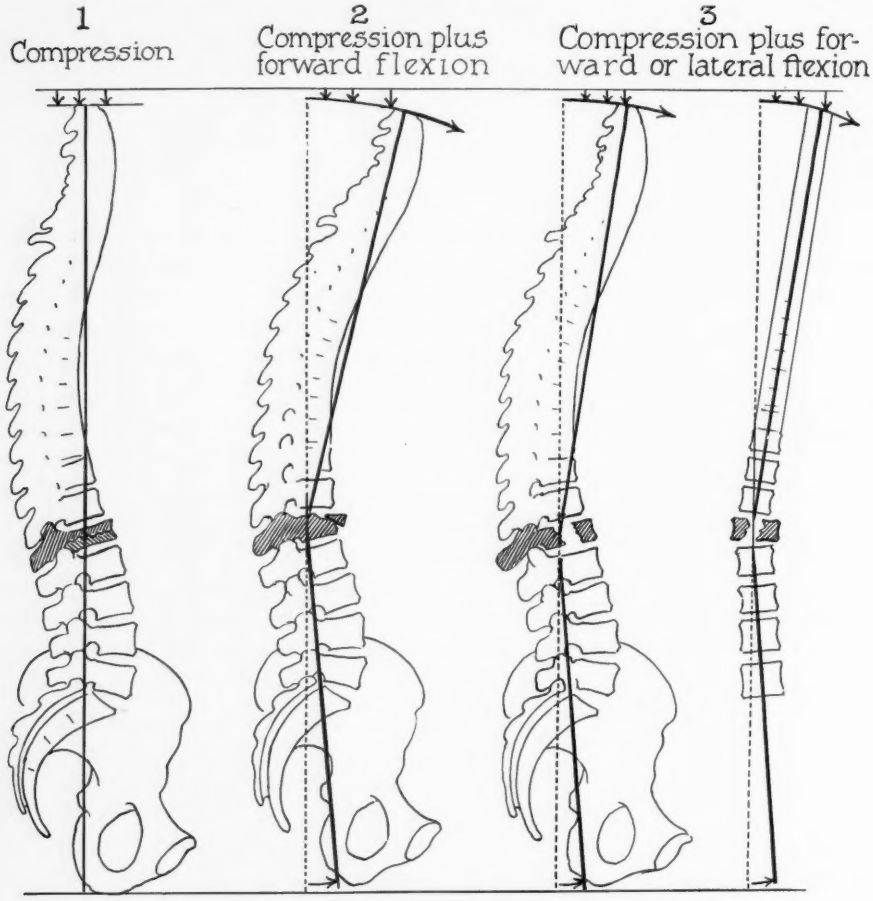
(4) The leverage action induced by flexion of the whole trunk forward aided by the architecture of the posterior articulating pedicles and facets attached to the arches and bodies, the rigidity and tensile power of the posterior and interspinous ligaments and the almost uniform tendency of the human body to fall in a position of flexion forward or laterally forward.

The middle portion of the corpus support weakened by venous sinusoids, and the late ossification of the middle of the body anteriorly where vessels enter, may be determining factors coupled with those given which cause the breaking off of a wedge-shaped piece from the upper anterior edge of the body caught in flexion pressure, or cause squashing compression of the whole body submitted to the more or less equal hydrostatic pressure of the intervertebral disks in pure compression applied in the long axis.

The main mechanism of fracture of the corpus vertebrae is undoubtedly compression. The rarer instances of injury from direct violence or fractures of the accessory portions of the vertebrae require less consideration. Compression sufficient to cause fracture must be applied directly in the long axis of the spine, aided by the incompressible intervertebral disks, and it is often complicated by flexion, generally forward, rarely lateral or hyperextension. Compression conveys force to those vertebrae which are located near the apices of the normal anatomic curves of the spinal column, especially from the dorsal tenth to lumbar fourth inclusive, which are less well supported by the ribs and contiguous structures resulting in crushing of the cancellous bone of the body and retention of an intact intervertebral disk. If no flexion accompanies compression, then the body is crushed and lessened in height quite uniformly, the posterior border in lateral view being reduced equally with the anterior border. The corpus tends to broaden laterally as does a crushed calcaneus and it may be separated into two or more fragments, one of which may push back into the canal to compress the cord, while the other may be displaced forward as far as it can go under the restraint of the anterior spinal ligament. There is no breaking off of triangular fragments at the border. If flexion forward and compression act together, there is broken off from the the anterior superior border of the corpus a wedge-shaped piece varying from a pea-size to nearly the whole anterior portion of the body, the plane of separation extending diagonally down and forward. The main portion of the body, especially the posterior, retains its height or diameter and the spinal canal is protected by the intact posterior longitudinal ligament while the anterior height is diminished with accompanying displacement forward of the whole spinal segment above, and resulting gibbus formation behind from the separated spinous processes after the interspinal ligaments are stretched or torn.

When compression is accompanied by lateral flexion the amount of comminution may be increased, one side of the body is crushed down more than the opposite side and displacement laterally into subluxation may be found. The body breaks into fragments easily through its weaker center, the seat of venous sinusoids. Other adjacent bodies may suffer similarly. One side

of the corpus of the vertebra may be found in the roentgenogram compressed and lessened in height when compared to the opposite side. The first roentgenologic study must compare the bodies immediately adjacent above and below the injured segment to search for breaking down of the bone along either superior or inferior border with early increased density, suggesting



MECHANISM AND RESULT OF FRACTURES OF THE CORPUS VERTEBRAE

Adapted from Roentgenologic Tracings

FIG. 1.—Pure compression fracture from violence received in long axis of spine without flexion. On lateral view the crushed corpus is narrowed quite uniformly compared to its neighbors; the posterior height is lessened yet equal to the anterior; the intervertebral spaces remain equal. The density of the bone may be increased from the intermeshing of cancellous tissue and the normal longitudinal axis of the spine may not be disturbed at all.

FIG. 2.—Flexion fracture with minor degree of compression. The anterior superior edge of the corpus is broken off; the fragment is displaced slightly forward; the posterior height of the corpus is normal and the intervertebral spaces usually remain equal to those adjacent. The main portion of the body does not change bone density. The superincumbent portion of the spine is flexed forward to a varying degree and there is a corresponding amount of gibbus formation at the fracture level. The arrows indicate diagrammatically the main lines of the force causing fracture. This is the common type.

FIG. 3.—Less common type with break through the weak center portion or fragmentation of the corpus and displacement of fragments. There may be a typical lessening of height of the body, fracture of the facets and pedicles and more evidence of cord pressure. Some instances viewed in the anteroposterior plane show lateral axis deviation of the superincumbent portion and the corpus may be correspondingly lowered in height on one side compared to the other.

Obviously, Types 1 and 3 require more care, greater traction and a longer freedom from weight bearing to restore the volume and integrity of the corpus vertebrae. Type 2 as a rule offers a better prognosis and a much shorter convalescence.

impaction of the cancellous tissue into itself. Later bone density changes indicate aseptic necrosis or if accompanied by new bone formation may require two to four months for demonstration in the film and depend on the amount of blood extravasation at time of injury, the period of immobilization used in treatment, and the secondary postural changes in the spine. The intervertebral disk may be ruptured and the nucleus pulposus evacuated.

The recognition of the retaining value of the anterior and posterior spinal ligament, of the intact pedicles and facets which afford leverage power during extension of the spine, induced Davis[4] to treat his patients by hyperextension in a prone position, hanging them up by their feet. This position pulled back into place the displaced fragments of the body, especially those caused by hyperflexion of the spine. Dunlop[5] used manual extension on all four limbs under anesthesia, accompanied by sudden forced hyperextension on a blanket or sheet, obtaining a maximal reduction in one quick action. Later special beds, such as Rogers[11] devised, were employed while the patient lay supine, to hyperextend the spine and by the felicitous action of its own ligaments and intact articular connections obtain reduction, with overcoming of the gibbus and angulation at the fracture site. Five years ago R. W. Jones[9] in Liverpool advised an easy correction without any anesthesia by letting the patient hang between two tables, one higher, supporting the head by resting on the crossed arms, while the legs up to the groin lay flatly on a table at a lower level. The weight of the midportion of the body brought sure and complete extension of the spine with reduction of displacement.

All these types of reduction by means of hyperextension with any required lateral flexion may be followed by plaster-of-Paris dressings much like that advocated by Böhler,[2] an encircling torso jacket resting on the hips, extending in front to the xiphoid notch and behind to the level of the inferior angle of the scapula, with a cut-away area for abdominal distension after eating. Many surgeons prefer to keep their patients supine on a plaster bed for six or more weeks in the position of hyperextension, to ensure which the plaster bed may be extended to the popliteal space under the thighs and half around the head above. Others have permitted immediate ambulation in the short torso plaster with the spine hyperextended. Operations on recent fracture to stabilize the spine by an implaced bone graft or a Hibbs operation have practically passed into disuse.

It will require the assembling of a large series of fractures of the bodies of the vertebrae treated by prolonged recumbency or by immediate ambulation after reduction by means of hyperextension to determine which method should be employed as routine. Series of roentgenograms over several years after reduction must be made to determine the final health and outline height as well as the structure of the compressed bodies. Clinically the amount of persisting pain must be gauged in this determination, always considering the original amount and character of the compression and displacement of bone. Discussion of Kummell's disease has purposely been avoided here. For over

20 years I have maintained that it resulted from mild and roentgenologically unrecognized compression fracture, permitted to go untreated.

After perusal of the many articles on this subject and an effort to analyze my own cases, it is my opinion that a few points in treatment require stressing. Each fracture of vertebral body should be studied roentgenologically before reduction to determine whether it was caused by pure compression in the long axis—with a squashed body easy to demonstrate early in the roentgenogram—or whether it was caused by compression flexion with a fragment broken off the superior surface of the body and displaced forward and downward. The third class of combined flexion and compression with lateral displacement may be recognized often by graver cord pressure symptoms but must be seen also in the roentgenogram.

If the fracture is the result of compression flexion with a relatively small fragment broken off the upper anterior border of the body, reduction by hyperextension by Jones' method or on a spinal bed which can be rapidly elevated into hyperextension at the site of fracture followed by an ambulatory plaster-of-Paris torso jacket for 10 to 14 weeks is sufficient treatment for most cases, during which time the patient requires no special exercises for his spinal muscles. In some individuals the amount of retroperitoneal hemorrhage from the fracture may induce abdominal symptoms, even a paralytic ileus, which will prevent all efforts at making the patient ambulatory and cause alarming complications. After removal of the plaster a roentgen ray study is made of the lesion and if the body of the vertebra seems restored to height and proper density with evidence of beginning reformation of normal trabecular lines, a spinal brace is applied and left on while the patient is on his feet until the roentgenogram shows full restoration of health and trabecularization of the bone. This may require a total of three or more additional months. With the passage of time the identity of fragments is lost, callus forms in the corpus, but some crushing deformity may persist. Hypertrophic new bone formation slowly appears and seems to envelop the body or advance along the anterior and posterior ligament to lock in the crushed bone.

For those patients who have sustained great compression with broadening or lateral gross displacement and uniform loss of height of the corpus, reduction by hyperextension plus traction in the long axis of the body is required in most cases. This is best done on a spinal bed with traction on head and feet. It does not seem necessary to hurry this reduction by sudden jolting hyperextension as it usually takes place smoothly in a few hours where sufficient force is employed. Evidence of cord pressure is a strong indication for this treatment. The symptoms may clear up rapidly. Immediate forceful hyperextension under traction and anesthesia is not advised.

A plaster bed or torso corset embracing the thighs may be used depending on the amount of dislocation laterally. These patients should be kept on the plaster, supine for eight to 14 weeks; ankylosis need not be feared. They may be rotated from side to side for gentle massage and back hygiene, not changing the position of hyperextension. Later they are fitted with a plaster-

of-Paris corset or back brace which is worn until roentgenologic demonstration of healed bone trabeculae is in evidence. This may require six to 12 months, depending on the patient's age and the amount of crushing of the body. If the back is unsupported there is a tendency for reformation of deformity, excess new bone formation, or wedge-shaped vertebral body along with continuation of pain. The spinal brace does not really interfere with action of the supporting spinal muscles, but acts as a constant reminder to the patient to stand in erect posture while ambulatory or sitting. During rest periods and at night the patient lies on a flat pillowless bed, brace removed. The structure and character of the repair in the corpus demand this safeguarding. Long continued extension and freedom from weight bearing are required to avoid extensive new bone formation and ankyloses between bodies, especially under the anterior ligament, and to maintain the normal height and size of the body if it has been regained by treatment.

REFERENCES

[1] Beadle, O. A.: The Intervertebral Discs, Medical Research Council, Special Report Series No. 161, London, 1931.

[2] Böhler, L.: Treatment of Vertebral Fractures. Arch. f. klin. Chir., vol. 173, p. 842, 1932; also Arch. f. klin. Chir., vol. 176, p. 123, 1933.

[3] Bowers, R. F.: Report of 40 Cases of Fracture of the Vertebrae without Cord Symptoms. Jour. Bone and Joint Surg., vol. 16, p. 583, July, 1934.

[4] Davis, A. C.: Manipulative Reduction in Fractures of the Spine. Am. Jour. Surg., vol. 15, p. 325, 1932.

[5] Dunlop, John: Correction of Compressed and Impacted Fractures of the Vertebrae. Jour. Bone and Joint Surg., vol. 15, p. 153, January, 1933.

[6] Evans, W. A.: Abnormalities of the Vertebral Body. Am. Jour. Roentgenol., vol. 27, p. 801, June, 1932.

[7] Felsenreich, Fritz: Modern Treatment of Uncomplicated Compression Fractures of the Dorsal and Lumbar Spine. Arch. f. klin. Chir., vol. 176, p. 123, 1933.

[8] Herzikoff, S. S.: Fracture Dislocation of the Fourth Lumbar Vertebra with Paralysis. Jour. Bone and Joint Surg., vol. 12, p. 403, April, 1930.

[9] Jones, R. W.: Treatment of Fractures and Fracture Dislocations of the Spine. Jour. Bone and Joint Surg., vol. 16, p. 30, January, 1934.

[10] Mayer, Leo: Correction of Lateral Compression Fracture of a Lumbar Vertebra. Jour. Bone and Joint Surg., vol. 16, p. 604, January, 1934.

[11] Rogers, W. A.: An Extension Frame for the Reduction of Fracture of the Vertebral Body. Surg., Gynec., and Obst., vol. 50, p. 101, January, 1930.

[12] Schmorl, G.: Die Gesunde und Kranke Wirbelsaüle in Roentgenbild. Georg Thieme, Leipzig, 1932.

[13] Schneck, F.: Reposition of Fresh Compression Fractures under Local Anaesthesia. Chirurg., vol. 2, p. 833, September 16, 1930.

[14] Wagner, G., and Pendergrass, E. P.: Intrinsic Circulation of the Vertebral Body with Roentgenologic Consideration. Am. Jour. Roentgenol., vol. 27, p. 818, June, 1932.

ARTHROPLASTY OF THE HIP AND THE PRESERVATION OF ITS STABILITY

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IN ANALYZING the reason for skepticism on the part of some regarding the wisdom of mobilizing ankylosed hips, one finds considerable difference of opinion among the best of surgeons. In most instances, however, the failure to secure active muscular stability, which many times results from the usual type of operation, is the reason. Henderson, reviewing the end-results of arthroplasties of the jaw, elbow, knee and hip, found those for the hip the poorest. The problem is obviously more complicated in weight bearing joints. The occupation and social status of the patient, as well as his temperament, are often determining factors, in deciding whether or not to operate, where the relationship of the femur to the pelvis is favorable. When the hip and knee on the same side are both ankylosed, the advantages of arthroplasty are much enhanced.

Stability by muscle action is very important at the hip, and, although the rotary nature of the joint lends itself to arthroplasty, unfortunate results have followed arthroplasty when stability was not obtained.

Arthroplasty in cases of tuberculosis should be approached with a great deal of conservatism and only when the roentgenogram shows evidence of complete disappearance of all disease and a complete homogeneity of bone structure throughout the operative field should operation be advised.

Murphy in 1904 reported his technic for arthroplasty of the hip, and in 1906, Hoffa[1] reported five arthroplasties of the hip (three by Rochet, and two by Nelaton[2]). From that time on, an increasing number are found in the literature. In fact, in my hands arthroplasty of the hip has become so dependable and well regarded that whenever doing an operation to stiffen a joint, if that case is a possible favorable one for future arthroplasty, I so plan my arthrodesing operation as to make it as favorable as possible for the future mobilizing operation. The points in favor of a future restoration of motion to a joint are: favorable age and temperament of patient, satisfactory degree of preservation of overlying soft parts and muscles, and satisfactory general condition of limb, including bone at site of proposed operation. In such a case, in doing an arthrodesis, I prefer to take bone elsewhere, rather than to disturb unduly periarticular structures or important surrounding muscles by obtaining the bone graft material locally. At the hip, tibial grafts are preferable, because of their adequacy of length and strength, thus making it unnecessary to incorporate them in the joint itself. If there has been an approximation of the great trochanter to the rim of the acetabulum, because

of telescoping from bone destruction, when it is ankylosed, then the graft material from the outer table of the ilium can be obtained of sufficient dimensions. Obtaining bone from the great trochanter has, besides the disturbance of the hip musculature, an additional disadvantage in that it shortens the trochanter-femoral neck leverage, an important item in muscle control of the hip. At the knee, for the same reason, I no longer employ the patella as a source for arthrodesing material. After its diseased portion has been removed, the patella is left as intact as possible.

To be classed as a good result in arthroplasty of the hip, there should be a minimum amount of voluntary flexion of at least 35 degrees. Everything being considered, a hip that possesses 35 degrees of painless, active motion, is far superior to a stiff hip. Not only should the hip joint have motion to allow proper sitting, but it should be painless and function in locomotion, particularly in bearing the weight of the body. It is far better to have a stiff, immobile hip than one accompanied by weakness and lack of satisfactory weight bearing or abduction. One author goes on to say that "the more nearly the joint is similar in size and shape to the original joint, the greater will be the stability. Hence, arthroplasty is not a resection!" This statement should be challenged. A ball and socket joint situated at the hip cannot have *per se* a desirable amount of motion and still be stable, because passive stability could only result from the capsule acting as check ligaments to motion, and this, in itself, would prevent adequate motion. Desirable stability with a large range of motion must come from muscle control. One frequently sees excellently functioning hip joints when there has been, from disease, an extensive destruction of bone and no semblance of a ball and socket joint remaining. The reason for this is that the muscle control is the all important consideration as to whether a hip is stable and whether there is a satisfactory amount of active motion and weight bearing.

To resolve the mechanics of the hip into simple terms, the hip joint itself is a fulcrum point situated at the end of a lever (namely, the neck of the femur) the distal end of which (or the great trochanter) is controlled by means of powerful muscles that are able, because of this mechanical setup, to pull or actively lift the limb at an angle with the pelvis, or abduction, which is a most important feature of locomotion in that it is the essence of weight bearing. In other words, it is impossible for an individual to bear weight satisfactorily on a limb when the hip is mobile unless the muscle control is such that the limb can be held so that it will not swing into adduction. This is brought about by the mechanical action of the abductor muscles of the hip pulling on the distal end of the lever; namely, the trochanter and the neck of the femur.

If this statement, used as a premise, is true and if it is possible to maintain this muscular control, then the careful modeling with the head of the femur fully filling a deep new-made acetabulum (with the difficulty of securing a free range of motion incidental thereto) is not necessary or desirable. The deeper the new acetabulum is made, and the corresponding femoral head

fitted to it, the less the chance of securing a good range of motion. Therefore, in selecting cases for arthroplasties of the hip, one should be sure that the muscles about the hip are reasonably preserved. Formerly, it was my practice to rule out cases in which there had been extensive shortening of the neck of the femur, either from bone destruction or from a telescoping of the head and neck of the femur into the pelvis, for the reason that even if the abductor muscles were intact one could never expect satisfactory function of active abduction because the trochanter-femoral neck lever would be still further shortened by the modeling of the new-formed hip, and thus furnish inadequate leverage for the abduction or weight bearing muscles to pull upon.

This was fully realized 20 years ago when designing my reconstruction-arthroplasty for ununited fractures of the hip with removal of the head of the femur, and placement of the denuded trochanter in the acetabulum; because of this, the leverage action of the neck of the femur that was lost was restored by lengthening the lever on the outer side of the long axis of the shaft of the femur by erecting, laterally and obliquely to the shaft, a bone muscle lever with the insertion of the hip abductors to its upper end undisturbed. Later, in order both to increase the length of this lever and to assure its maintenance, the removed femoral head was shaped as a wedge and placed so as to hold it outward. In this way, one is able in such cases, even in the complete absence of the head and neck of the femur, with the denuded trochanter placed in the acetabulum, to establish a lever equally as long as the normal trochanter-neck lever of a normal joint. Whether the resulting reconstructed joint follows a nonunion, or a shallow modeled acetabulum of an arthroplasty for ankylosis, the mechanical conditions brought about in the above manner prevent dislocation when the limb approximates the midline, which is a real hazard, unless provided against. The *modus operandi* is as follows: As the limb seeks the midline, the upper end of the erected bone graft lever travels farther and farther away from the rim of the acetabulum and the side of the pelvis, and thus not only puts an increasing tension on the short abductor muscles but also on the surrounding fascial structures, thus holding the head of the femur securely in the acetabulum.

Because of the very satisfactory experience with this mechanical setup in a large number of cases of ununited fractures of the hip, I began 10 years ago to apply the same principle to cases of arthroplasty where, because of bone destruction, the trochanter-neck lever is practically absent or much shortened, and a satisfactory result by arthroplasty alone not possible. Therefore, in recent years, the destruction of the head and neck of the femur (with telescoping) has not been a deterrent influence to me in selecting cases for operation, in that I have found in doing an arthroplasty that a hip joint could be modeled with the head of the femur much smaller than the acetabulum, with sufficient fascia and fat to fill in the interspaces, and that the mechanical influences brought about by the provision of leverage action for muscle control on the outer side of the trochanter not only prevented dislocation, but allowed active abduction and satisfactory weight bearing.

Case Report

Miss H. H., aged 32 years, came to me July 11, 1924, referred by Dr. G. W. Crile. She had suffered from ankylosis of both hips, apparently the result of suppurative arthritis. In 1917, an arthroplasty had been performed on the left hip, and in 1919, on the right hip, by Dr. Carl Hoy of Columbus. Excellent motion was obtained in both hips. The right hip, however, was a serious disappointment because of instability and constant danger of dislocation whenever the limb came to or beyond the midline.

This case presented three features: (1) a constantly recurring dislocation of the hip whenever the limb swung to the midline or beyond, (2) loss of the function of abduction, and (3) loss of active weight bearing. These are the very conditions which the present bone-muscle lever was designed to overcome or prevent.

Operation.—July 14, 1924, at the New York Post-Graduate Hospital, was therefore approached with a great deal of interest by myself and my associates. The newly formed joint resulting from the previous arthroplasty was found to be an excellent false joint,

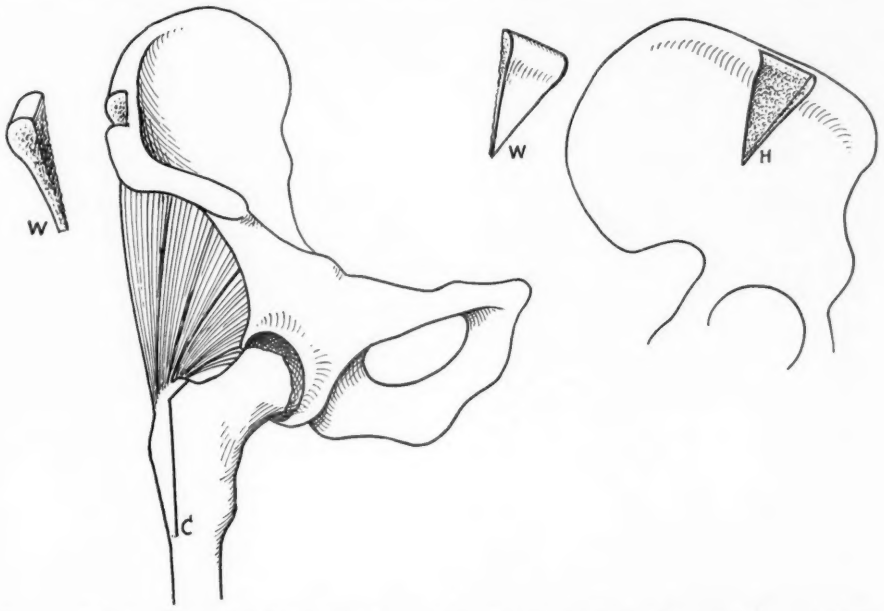

Fig. 1.—Drawing illustrating first steps of operation, showing the lines of proposed bone incisions.

with a well formed acetabulum, containing clear liquid, quite closely resembling synovial fluid. The femoral portion of the hip, however, was merely the stump of the neck. The hip was very relaxed, and could be readily dislocated. The bone muscle lever was erected from the outer and upper end of the femur, precisely as described. In May, 1925, the patient wrote that the hip was strong and had not dislocated, and that she considered the result excellent.

Technic.—The patient should be placed on a fracture orthopedic table. The Smith-Peterson approach affords such satisfactory exposure that it is the incision of choice for all intra-articular operations. The incision begins at a point about four inches below the anterior-superior iliac spine, and is carried along the outer border of the sartorius muscle, upward to the anterior spine and thence backward, following the iliac crest. The gluteal muscles are detached and reflected subperiosteally from the wing of the ilium downward *en masse*, thus giving a wide exposure of the hip joint.

By means of a large carver's or Murphy's gouge, the femur is separated from the pelvis, care being taken to make the bone incision in such a way that a rounded femoral head and a corresponding acetabular cavity are shaped. The acetabulum is not shaped nearly as deeply as formerly, because of the fact that I find the present technic obviates the danger of dislocation, and further that this is a very satisfactory influence in bringing about a greater degree of ultimate motion. The various carver's gouges and chisels are of great service in plastic bone work, especially in arthroplasties. The large variety of cutting edges and curvatures of the chisel or gouge enables the surgeon to select the proper tool for almost any emergency.

After the general contours of the joint are thus blocked out, the surfaces are merely smoothed and transformed into regular spherical convex and concave surfaces by arthroplastic hip rasps, modified from Murphy's. The concave and convex rasps are placed in between the femoral head and the acetabulum and these surfaces smoothed and shaped by a to-and-fro motion of the handle, in the manner of a spoke of a wheel. The tools will execute this work faster if an assistant pushes upward on the patient's knee. These instruments enable the surgeon to shape accurately the inner portion of the joint which cannot be seen or gotten at by an ordinary instrument.

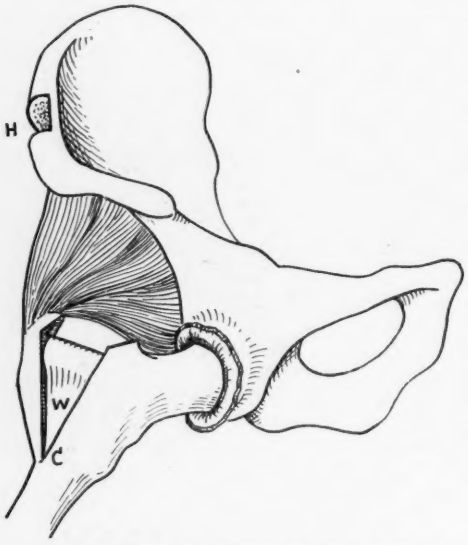

FIG. 2.—Drawing illustrating later steps of operation, with graft (W) obtained from ilium at (H) inserted into triangular space at (C), thus elongating the trochanter-neck lever for weight-bearing and the function of abduction.

The next step is to apply traction to the limb, to separate the head from the acetabulum, so that the bone particles can be washed out by means of a glass cannula connected with a fountain of saline solution over the table, and to allow the easy insertion of the fascial flap, about to be obtained from the thigh, lower down. A semicircular skin incision is made on the outer side of the thigh, midway between the hip wound and the knee, and a quadrilateral piece of fascia lata with as much fat as is obtainable, about four inches long by three and one-half inches wide (in adults) is secured. The subcutaneous layer of fat is divided in equal halves, one-half being left attached to the skin, and the other half to the graft, which is subsequently to be removed. With a small curved needle, stay sutures are placed in what are to be the two inner corners, and the fascial graft is drawn in and pushed into the inner confines of the new joint by some instrument as far as possible between the new joint surfaces. Additional sutures are then placed about the periphery of the graft. The fascia is carefully approximated by a continuous suture of No. 1 chromic catgut.

If, at this point, it is thought that the leverage action of the neck of the femur is not sufficient, a bone fragment, consisting of the tip and the outer surface of the trochanter of a varying length (approximately three and one-half inches) is separated with a broad thin osteotome, with the insertion of the abductor muscles intact (Figs. 1 and 2) and swung outward from the shaft of the femur from 20 to 35 degrees, by producing a greenstick fracture at its lower end. Into this triangular space, between the remaining portion of the shaft of the femur and the bone fragment, a segment of the crest and outer table of the ilium is fitted (Figs. 1 and 2). This graft may be supplemented by fragments of cancellous and cortical bone, also obtained from the ilium. This bone-muscle lever operation may be done at the same time as the

FIG. 3.—Roentgen ray of ankylosed hip of eight years' duration, following suppurative arthritis. (Case of L. G.)

FIG. 4.—Roentgen ray of hip (case of L. G.) after arthroplasty. Full range of passive motion of hip. Patient walks very well with cane. Without cane, walks with limp.

arthroplasty, or at a later date, as the surgeon thinks best. The soft parts are approximated by a continuous suture of chromic catgut No. 1. The skin is closed by plain catgut No. 0. Dressings and stickers to the thigh are applied. With the limb in moderate abduction, a plaster of Paris spica is applied from above the costal margins on the opposite side to the toes, with stickers coming out through the plaster, above the ankle. From 15 to 20 pounds of traction with pulley and weight is applied immediately and maintained for three weeks after the removal of the plaster spica (three weeks postoperatively), or until a Taylor traction brace or Thomas knee brace is applied, and locomotion with crutches is allowed.

This brace should be continued for at least three months before weight bearing is permitted, during which time or longer, daily massage and active and passive motion are carried out. Traction is most necessary and should be applied before the patient comes out from under the influence of the anesthetic, because of the devitalization and crushing effect that would otherwise be produced on the fascial graft by the involuntary contraction of the powerful thigh muscles. I have found that with a pulley and rope erected over the bed, fastened to a sling beneath the knee, the patient is able to help very materially in mobilizing the joint by constantly pulling the hip into flexion. This engages the patient's attention, and is a real help as a part of the postoperative physiotherapy.

FIG. 5.—Roentgen ray of hip (case of L. G.) after erection of trochanter lever by means of wedge graft from ilium. Note hip is in abduction, following operation. W indicates graft.

FIG. 6.—Roentgen ray of hip (case of L. G.) two months after second operation, showing adequate lever for function of muscles attached to great trochanter. Patient was able to walk well without cane.

SUMMARY

A ball and socket joint, particularly the hip, with its anatomic provision for muscular control, cannot be stabilized by modeling of the joint contours alone; the fit of a ball and socket joint in machinery may be so accurate as to be within a few microns and still the motion be as free as with a loose fit.

The stability of a freely movable hipjoint, particularly in weight bearing, which is the most important consideration, must be through the medium of muscle control, especially the short trochanteric muscles and their pull upon the trochanter-femoral neck lever. In most arthroplastic procedures, this lever is either shortened to such a degree that it no longer functions, or it may be entirely obliterated. Hence, the necessity for its elongation or restoration by surgical means.

REFERENCES

[1] Hoffa: Ztschr. f. orthop. Chir., vol. 17, p. 1, 1906.

[2] Nelaton: Bull. et mém. Soc. de chir. de Paris, vol. 28, p. 687, 1902.

THE TRAUMATIC KNEE

STATISTICAL SURVEY OF ONE HUNDRED AND FORTY-SIX CASES

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THE economic value of the knee is only realized after injury. Industrially, the knee rivals the back in importance and the diagnosis and treatment of knee injuries are of paramount interest to the working man whose livelihood depends upon its integrity. In the past seven years I have performed 146 major knee operations and a critical review of these cases forms the basis of these observations. Restoration of function and an earning capacity with freedom from pain are, in the final analysis, the crucial points to be considered in determining the value of any given procedure, operative or otherwise. As the series progressed operative procedures were changed to shorten the time of knee joint exposure and particularly to adopt a standard of approach, and a postoperative procedure which would afford the patient the greatest advantage and result in minimal functional defect.

Historically, the knee joint has commanded the interest of surgical generations beginning with the observations of Hippocrates who recorded detailed methods of reducing the dislocated knee. Knee joint history was made by Vesalius, who was the first to recognize that dislocations followed very insignificant accidents which the patient could reduce himself; by Ambrose Paré, who in 1558 removed the first joint mouse; by William Hey, who in 1784 was the first to describe semilunar dislocations; by the Weber Brothers in 1836, who first placed the mechanism of the knee joint on a scientific basis, and by Meyer, who demonstrated the screw mechanism of the condyles and the function of the crucial ligaments. The resurrection of surgical interest was made by Thomas Annandale in 1885 when he sutured the semilunar cartilage. Allingham, Martin and Timbrell Fisher have also made epochal contributions to knee surgery.

ANALYSIS OF 146 KNEE JOINT OPERATIONS

Right knee involved	72	Internal	81
Left knee involved	74	External	2
Male	140	Transverse	45
Female	6	Anterior third	38
Extensor apparatus	18	Middle third	4
Quadriceps rupture	4	Posterior third	3
Fractured patella	12	Longitudinal, marginal or "bucket-handle"	38
Patellar ligament rupture	2	Locked	6
Semilunar lesions	83		

ANALYSIS OF 146 KNEE JOINT OPERATIONS (*Continued*)

Complications:		Complete tear of anterior crucial ligament	4
With partial tears of anterior crucial ligament	7	Joint mice	12
With associated lesions of the fat pads (Hoffa's disease)	25	With osteo-arthritis dissecans	6
With osteo-arthritis	9	Giant cell sarcoma	1
With acute gonorrheal arthritis	1	Cyst of semilunar cartilage	3
With villous synovitis	4	Fracture of tibial spine	1
With popliteal ganglion	1	Fracture of tibial condyles (intra-articular)	5
Hoffa's disease uncomplicated (one locked)	5	Infection (operative—extra-articular)	1

Several of these cases are worthy of comment: Six cases required reoperation.

CRITIQUE OF THE SIX REOPERATED CASES

(1) E. T. is cited because at the first operation there was failure to recognize a torn crucial ligament when removing an internal semilunar cartilage. At the second operation after several months' disability the collateral ligaments were plicated with complete restoration of function and security.

(2) L. B. came to reoperation eight months after removal of an internal semilunar cartilage with persistent symptoms of intermittent pain and disability caused by a pinched fat pad. This same case was reoperated one year later for a torn internal cartilage of the other knee. Additional fat pads were removed at this operation.

(3) J. V. was operated for the removal of an internal cartilage and a chondral cyst of the external cartilage which had pushed its way through a split in the lateral ligament at its midpoint. He came to reoperation for recurrence of the cyst one year later.

(4) L. G.'s right internal semilunar was removed and nine months later the left was removed for a second accident.

(5) M. D.'s right knee was operated on for the removal of a joint mouse which had detached itself from the internal condyle of the femur. With the persistence of the same symptoms for nearly a year, it was found upon reoperation that a torn semilunar cartilage had been overlooked.

(6) I. S. was a refracture of the patella caused by too vigorous massage before union had become consolidated.

Several other cases are worthy of comment.

L. F.'s synovial membrane was so intensely congested that it was not until after the removal of his torn semilunar that it was learned that he had had a recent gonorrhea. He made an excellent recovery, however, after a prolonged convalescence.

T. M. had his anterior crucial ligament completely torn and both semilunars detached anteriorly. H. G. had a torn anterior crucial ligament and a torn anterior end of the external semilunar cartilage. T. D., five years posttrauma, had a torn anterior crucial, a joint mouse and a bucket-handle internal cartilage. J. P. and L. W., a torn anterior crucial ligament with a foreign body. W. C., an internal semilunar with joint mouse, removal one year later, and M. D.'s joint was blocked in extension by an interposed hypertrophied fat tab.

The one case of giant cell sarcoma was peculiarly pedunculated—an extra-articular mushrooming from the epiphyseal region of the external femoral condyle, the size of a walnut, which had been fractured at the pedicle.

In the cases of 12 joint mice, five had arisen from the cartilaginous surface of the internal, one from the external femoral condyle (osteochondritis dissecans) and another had apparently arisen from the tibial tuberosity.

There were 25 cases of redundant fat pads. Five cases were independent of torn cartilages. In one case the pinching as indicated by the fibrous synovial tips was bilateral and removed by bilateral incisions. In two cases of semilunar cartilage removal it was necessary to reoperate for the neglected removal of fat pads at the first operation. A fat pad caused locking in one case.

In this series there was one infection; this had been extensively laid open through the extracapsular portion of the knee for the repair of the patellar ligament and tissues lateral to it. A large hematoma developed which subsequently became infected.

To recapitulate the observations on this series of 146 cases: There were four errors (failure to recognize two troublesome fat tabs, one cartilage in a joint mouse case and a crucial tear in a cartilage case) and one extra-articular infection. The errors were all corrected by reoperation.

Before the consideration of the traumatic intra-articular lesions, let us briefly comment upon injuries to the extensor apparatus. The same forces and mechanism operate in the lesions of a torn quadriceps, a fractured patella, a ruptured patellar tendon or an avulsed tibial tubercle. It is merely the point of stress involved. Consider this group as an entity. The cardinal symptom of all is a defect in the extensor mechanism. A sesamoid bone is not designed for strength but is a spreader to protect a joint. The fact that the larger percentage of lesions of the extensor apparatus involve the cancellous patella argues its relative weakness in comparison with the distributed strength of the fan-shaped suprapatellar support or the concentrated cable-like arrangement of the infrapatellar tendon.

Fifteen years ago Mrs. C. L., advanced in pregnancy, while descending some steps on a cold morning, reached behind her to gather in her coat belt, and as she bent backward with her weight back center she felt a sudden snapping at both knees and sank to the steps with a tearing sharp pain. Both patellae were simultaneously fractured. Recently my hospital associates repaired a bilateral quadriceps rupture. Bilateral lesions are not rare.

Paradoxically, the essential lesion of a fractured patella is the soft part damage to the lateral vasti muscles. Their approximation is paramount to the security of the repaired patellar fragments and its omission may contribute to functional failure. It is essential to remove the clots from the joint and to mosaic the larger comminuted fragments into place—never remove large fragments.

Controversy still wages as to technic, suture material and postoperative treatment. I have personally obtained good results from the routine use of a wide curvilinear subpatellar incision with complete exposure of the lateral vasti muscles; the removal of joint clots without irrigation; the repair of the soft tissues by heavy kangaroo tendon, mattress fashion; the replacement

and rematching of the comminuted fragments; the use of a single strong kangaroo suture inserted through the drilled upper and lower fragments and a circular case.

I am opposed to making the incision at the line of fracture, irrigation of the joint with saline or ether, use of unabsorbable patellar sutures and untimely preoperative delay. Unless there are patellar abrasions I can see no reason to delay operation seven to ten days. I believe the repair should be made at once. I use a circular case to prevent a damaging postoperative effusion and to protect the sutures. It acts as a buffer against which reaction can end and absorption begin.

The repair of the quadriceps is a matter of interrupted kangaroo mattress sutures but the repair of the patellar tendon is frequently troublesome. In all cases, the suture of the lateral extension is paramount. In a recent patellar tendon repair I varied the technic by splitting the lower half of the patella vertically, inserting the patellar tendon into the slot and securing it by a transverse drill hole impaling the tendon with a kangaroo suture.

One of the most frequent intra-articular lesions is the common "bumper fracture," involving the external tuberosity of the tibia. Depressed fractures of the tuberosities altering the alignment of the articular surfaces of the joint give bad after-results unless the alignment be reestablished by open or closed correction. Manipulation and moulding may realign the gliding surfaces but if the check-up plates are not satisfactory, by all means consider operation imperative. Bearing in mind the neurologic anatomy of the lateral aspect of the joint, the depressed tuberosity can easily be pried up and pushed or hammered into normal alignment. The procedure is simple, effective and essential for function.

There are certain anatomic requisites necessary to the understanding of the mechanism of semilunar damage:

(1) The anatomic balance of the knee is an engineering triumph—designed, however, for all stresses but torsion.

(2) Mechanically, the joint has a three point suspension—hung, as it were, anteriorly by the quadriceps, postero-internally by the semimembranosus, postero-externally by the biceps tendon. These points are reinforced medially by the strong internal lateral ligament, the tendons of the gracilis, semitendinosus and the sartorius, and externally by two strong collateral ligaments. These muscles pull the leg upward against the head of the femur, while as a counter pull, the popliteus and the two heads of the gastrocnemii posteriorly secure the femoral condyles against the tibial tuberosities. This muscle tripod, the lateral and capsular ligaments, secure the joint externally whereas internally the crucial ligaments lend strength, but only for anteroposterior stress, and the semilunar walls tend to prevent lateral displacement.

(3) The strength of the joint is paradoxically dependent upon and commensurate with the strength of the thigh and calf muscles. That sense of "knee weakness" is felt by those with atrophic muscle changes with the resulting loss of the "counter pull." The knee, then, reaches maximum strength

in extension and is weakest in flexion, when the counter pull is relaxed. Most traumatic lesions, therefore, occur with the knee in partial flexion.

(4) The sheering action of torsion lesions occurs only on the anterior part of the joint because the body weight assists in tearing or breaking the anterior knee mechanism when in partial flexion. The flexors, wherever situated, are always more powerful than the extensors and moreover the anterior portion has no femur-to-leg pull such as the strong down pull by the gastrocnemii posteriorly. This accounts for the predominance of stress damage to the extensor apparatus and the absence of posterior knee lesions.

(5) The displacement of the anterior end of the internal semilunar cartilage is accomplished by an inward rotation of the femur with the foot fixed or inward rotation of the leg and foot with femoral fixation; whereas the external semilunar cartilage is displaced by the outward rotation with the foot fixed or outward rotation of the foot with the femur fixed. Abduction and flexion of the knee are essential with torsion. The mechanism which accounts for the greater percentage of semilunar tears is an inward twist of the femur when the knee is flexed, the leg abducted and the foot fixed—or its converse, a twist of the foot with the thigh fixed. Arising from the squatting position has given the condition the name of "miner's disease." Martin found 62.8 per cent of his cases among miners and 18 per cent among football players.

(6) In Martin's series 92 per cent were the internal cartilage, Henderson's 94 out of 98, and in the past seven years I have had but two cases of external cartilage damage in 83. The relative freedom of the external cartilage to injury is explained by (1) the fact that the internal cartilage is firmly attached to the internal lateral ligament in its posterior half whereas the external lateral ligament is freely movable over it, and (2) the external semilunar cartilage is more movable and adaptable, (3) the anterior horn of the internal semilunar cartilage is relatively less firmly secured to the upper surface of the tibia and (4) the internal cartilage is more exposed to the sheering violence as it is C-shaped, whereas the external cartilage is almost circular and does not therefore resist torsion.

(7) Thirty-eight of the 83 cases herein reported were of the bucket-handle type in which there is a longitudinal splitting or marginal separation with displacement of the cartilage wholly or in part into the intercondylar space. The mechanism of this type is explained by Fisher as a result of a more severe rotatory movement in which the internal lateral ligament is torn from its cartilaginous attachment and if abduction be a marked feature of the case, the midportion of the cartilage slips into the interior of the joint and when extension occurs the cartilage is split longitudinally when the condyle of the femur is jammed down upon it, producing a typical "bucket-handle" lesion. In his series the longitudinal type predominated—38 per cent.

(8) The early changes in the joint are extravasation of blood in varying amounts, synovial effusion, followed later in neglected cases by thickening of the capsular ligament, circulatory changes in the articular cartilages with

granulation tissue spreading in from the osteochondral margins and atrophy of the quadriceps group. Finally, cartilages may become eroded or destroyed, the fat tabs become enlarged and edematous, villous papillae begin to appear and the joint terminates in arthritis and hypertrophic osteo-arthritis.

Etiologically, the condition is found at all ages, especially in muscular types, rarely in women, rarely by direct violence, and rarely is the external cartilage involved, indicating that internal wrenching with flexion of the knee, abduction of the leg, and fixation of the foot is the prevailing causal mechanism.

When the essential torsi-flexion mechanism has been executed there follows a sequence of symptomatic events which are initiated by pain, followed immediately by muscle spasm, and if the muscle spasm begins before the knee has, as it were, untwisted itself and the cartilage disengaged, the cartilage becomes damaged and the knee locks at once. Not infrequently the patient maneuvers the leg himself and frequently he will describe snapping it into place. The click may be audible. Many cases are immediately locked and remain so until the time of operation. I recall three instances in which a knee was unlocked, so to speak, upon administration of spinal anesthesia.

Effusion or pain is conducive to limited motion. Gradually as the fluid and the pain subside, motion is restored until at a later date the locking episode occurs again with the return of the same symptom complex. Locking of the joint is not essential for a diagnosis. In my experience I would estimate one-third of the cases gave no history of locking.

One must make careful inquiry as to just what the patient means by locking. I have so many times been convinced that a given joint did not "lock" but upon analysis there was merely a clicking sensation. When the joint is locked it is fixed in extension—rarely in flexion. It has been my experience that the so called blocking mechanism occurs in cases of transverse laceration of the cartilage at about the anterior third with doubling up of the anterior fragment; or in such cases of longitudinal splitting wherein the inner condyle of the femur has, as it were, buttonholed itself through; and in this manner extension is made impossible.

Not infrequently one can diagnose some of the types of laceration by the history. It has been my experience that complete transverse fractures usually lock the joint by buckling up in front of the condyle of the femur and preventing complete extension. Many of the bucket-handle type or longitudinal splitting are those which lock the joint at frequent intervals, sometimes as frequently as five or six times a day. The inner portion of the cartilage splits longitudinally or marginally, does not become detached at the ends but shifts from its normal position at the outer margin of the condyle back and forth into the intercondylar space and the joint is never totally locked or blocked except when the longitudinal splitting extends to the very anterior attachment. The crushing at the midportion wherein there is an incomplete fracture rarely, if ever, locks but gives continued pain, partial disability and intermittent periods of effusion. The point of tenderness is on the lateral side of the joint and is very well localized. In the circumferential type, after the initial locking,

the joint rarely locks again, but this type of knee is a prolonged source of pain and partial disability. Tenderness extends from the anterior end far back laterally. Locking does not occur unless the cartilage becomes dislocated into the intercondylar space.

Upon examination there may or may not be effusion into the joint. In the early stages effusion is the rule. The joint rarely crepitates upon manipulation but there is a varying degree of limited motion depending upon whether the joint is locked and whether the case is early or late. In the neglected cases there is a resultant disuse atrophy particularly involving the extensor group of muscles. There develops an interstitial myositis with fibrous contractural changes which prevent complete flexion. In these cases wherein the atrophy is noticeable there is always a limitation of from 10 to 45 degrees of motion. This interstitial myositis is due to disuse, apprehension of the painful recurrence of the locking episode and in many instances or, shall we say in most instances, to the various forms of supporting kneelets or elastic bandages which are at times unfortunately applied to tourniquet constriction.

In the interval between the locking episodes, the knee joint is frequently not painful and many patients will tell you that straight line walking, mounting stairs, *etc.*, is painless but as soon as the toe is stubbed and the foot twisted sharply inward or outward they get sharp pain referred in all instances just lateral to the lower patellar pole. The lower pole of the patella is the landmark of the articular junction between the tibia and femur. Just lateral to this is the point of attachment of the anterior end of the cartilages and point tenderness is one of the essentials of the diagnosis. Tenderness may extend as far back as the midquadrant. Continuous line tenderness is suggestive of a splitting of the cartilage from its coronary ligament attachment whereas the tenderness midway back is suggestive of the transverse type of fracture, complete or incomplete.

Not infrequently, with the knee in complete extension, there is in the bucket-handle type a dimpling in along the anterolateral margin of the knee due to the intercondylar displacement of the meniscus. Not infrequently a loose fragment in thin individuals is palpable over the anterior end of the internal semilunar cartilage and the small mass has often been pointed out by the patient himself. One should be satisfied, however, to make the diagnosis of a torn cartilage without attempting to differentiate the pathologic type. It is amazing, however, in seeing a large number of these cases to learn how comparatively accurate one may become in differentiating the varying pathologic varieties.

Effusion is a protective biologic reaction which separates the damaged parts, and at the same time, by the distention of the joint, it is immobilized in semiflexion. By distention, a joint sometimes becomes unlocked due to separation of the articular surfaces, permitting the fibro-elastic cartilage to snap back into place with relief of pain and muscle spasm. The aspiration of a joint in many respects, therefore, is unphysiologic and the reduction in volume

were better handled by external pressure rather than the sudden withdrawal of the fluid which is in nearly every instance followed by a reaccumulation.

Atrophy is not a symptom; it is a sequela. As previously related it is due to disuse and too long continued circular compression by elastic knee supports or unduly tight bandages. As time progresses atrophic changes increase and sooner or later an interstitial replacement fibrosis ensues which greatly, and may permanently, impair motion. It is for this reason that early operation is indicated, and it is for this reason that many disappointingly high percentage losses are encountered when operation has been deferred too long. Cases in which atrophy exists with marked restriction in flexion should be given a preoperative manipulation to overcome, if possible, the fibrosis. Above all, active exercise is encouraged to maintain muscle tone and joint security.

In the diagnosis of the case, therefore, a very careful history should be taken in which the patient should describe in intimate detail the onset of the identical mechanism which produced the sudden pain. The history is one of the essentials of the diagnosis. There are other pathologic conditions which may cause locking of the joint and a radiograph is always essential to exclude mechanical obstruction. While locking of a joint is suggestive of internal derangement it is absent in at least one-third of the cases. Tenderness localized over the torn cartilage, a varying degree of restriction of motion, fluid, and atrophy complete the picture. The essentials, therefore, are the history of sudden torsi-flexion violence followed by pain and effusion with or without locking of a joint, marked tenderness at the point of the lesion, lack of response to physiotherapy, and, in late cases, a flexion defect due to atrophy.

Pneumo-arthrosis with oxygen, nitrogen, or carbon dioxide has been discarded as being of insufficient diagnostic value.

Never fail to have comparative radiographs made. I have compared films with operative findings and am thoroughly convinced of the fallacy of a radiographic diagnosis of a torn cartilage. The diminution of the space between the condyle and tuberosity is not pathognomonic of the lesion and obviously so because the cartilages merely act as packing agents or a filler for the triangular chink between the outer joint margins circumferentially, and are not interposed between the two bones.

By placing the roentgen ray tube in various positions we can change the spacing between the two opposing osseous femoral and tibial bodies. I have demonstrated on numerous occasions a diminution of the joint space in the nontraumatic and normal knee. The radiographer can contribute in assisting in the diagnosis with the exception that a so called negative film is what is to be looked for to differentiate in the diagnosis as against such locking as might be produced by a foreign body. The roentgen ray, therefore, is essential not in the diagnosis but in the differential diagnosis, except in the neglected case where the cartilage may undergo some slight calcific change, to be detected along its margins.

The radiographs in suspected knee lesions must be critically searched in making the differential diagnosis. The margins of the femoral condyles should

be closely scanned for irregularities as are seen in osteo-arthritis dissecans which so frequently form the nest of the joint mouse. Foreign bodies of the osteochondral type should be looked for. The varying hamstring sesamoids should be excluded as intra-articular by their margins and contour, but may I state again a torn internal semilunar cartilage with but one exception gives a negative film. I had occasion not so long ago to observe a knee locked in extension. As soon as the patient was given a spinal anesthetic the knee could be freely put into complete extension after the muscles had been relaxed. Upon opening the joint I found the joint space had been widened fully an eighth of an inch by the interposed doubled up cartilage and upon review of the films again after operation I found the joint space between the femur and tibia on its internal side was greater than on the external side. An increase but certainly not a diminution in the joint space, therefore, may be of some diagnostic value.

A point of diagnostic interest is to place tension upon the torn cartilage in the following manner. While the patient is sitting on the examining table with his extremity at 180 degree extension, flex the knee slightly to relax the muscles and fix it firmly against your own body. With the other hand grasp the foot and gently rotate the leg inward. Pain is noted at the attachment of the anterior end of the external semilunar cartilage, if the lesion is there. Then, rotate the leg outward, putting tension on the fibers of the internal semilunar cartilage and by overstretching the fibers, if torn, the pain will be greatly aggravated.

In the differential diagnosis one ought readily to exclude a tear in the internal lateral ligament—rarely complicated by fluid, never locked, tenderness localized on the medial surface, usually, and increased by tension on the ligament—namely, abduction at the knee while the leg is in extension.

The locking due to foreign body can at times be palpated and readily excluded radiographically.

Diagnostically, then, we are left with but three other conditions—osteo-arthritis dissecans, a pinched fat tab, first described by Alfred Hoffa, and the torn crucial ligaments.

In the former condition a very critical review of the radiographic contours of the internal and external condyles of the femur will be sufficient to make the diagnosis. In these cases clinically the point of tenderness is close to the patella on the condylar surfaces of the femur; whereas in semilunar cartilage damage tenderness is at its attachment along the margin of the tibial tuberosities and in Hoffa's disease the tenderness is just lateral to the patellar tendon so that we have points of tenderness in these three conditions mentioned, respectively forming a triangle with the tenderness above in the dissecans pathology, tenderness below and to the outer side in meniscus damage, and tenderness internally and below in the fat tab syndrome.

The differential diagnosis of the fat tab, Hoffa's disease, as it is sometimes called, is made by exclusion. I believe the mechanism in this case is due in most instances to direct violence with a hemorrhage inside the capsule

and subsequent edematous changes in these two folds of fatty tissue which lie beside the alar ligament just internal to the anterior attachment of the semilunar cartilages and immediately lateral to the patellar ligament. When this fatty tissue becomes traumatized, usually by direct violence, the traumatic reaction puffs out these fatty festoons and with the sudden extension of the leg there occurs a sharp pain of a pinching type. It does not cause locking, but a sudden muscular spasm occurs to fix the joint in order to prevent further pain. This leads many patients to describe the episode as locking, whereas it is essentially a pinching plus a muscle spasm. As previously pointed out the tenderness is close to the patellar ligament and not proximal to the femoral condyle nor the meniscus attachment. Moreover, the pinching episode does not come on at the time of the initial violence but at a later date and only comes on in complete extension when the fatty tissue is relaxed and, as it were, gets caught between the tibia and femur. The locking episode is essentially a fixation from pain and not a mechanical blocking such as we get in cartilage derangement. Pathologically the fatty festoons become fibrous from repeated pinchings. In many instances the symptom complex can be differentiated from that of the torn cartilage.

The rupture of the crucial ligament is associated with severe violence and is followed by hemarthrosis and rapid effusion. Semilunar pathology may coexist. The test for a torn anterior crucial ligament is the so called "drawer sign" in which, seated before the patient, with his knee at 90 degrees the leg can be pulled forward by the examiner or can be abnormally hyperextended or rotated; whereas when the posterior crucial is torn, the leg can be pushed backward when the knee is at 90 degrees.

The prognosis depends upon the time elapsed between accident and operation, age of patient and whether or not osteo-arthritic, arthritic or atrophic changes have developed. The average early case should obtain a favorable recovery without limitation of motion. The late cases with coexisting pathology and atrophy will have a percentage residual limitation, which, however, should never exceed the preoperative restriction. Cartilage removal will not overcome arthritic or osteo-arthritic changes nor will it improve muscle atrophy if dependent on organic muscle fibrosis, although definite benefit will be obtained by removal of the offending cartilage regardless of other existing pathology. The prognosis also depends upon whether the associated pathology will have been corrected at the time of operation. Failure to remove all the foreign bodies, pinched fat tabs, failure to recognize torn crucials or the "other" torn meniscus—all contribute to a poor prognosis.

With, however, early operation, in the absence of quadriceps atrophy, the employment of a small incision, and minimal operative insult, a lasting benefit without functional defect should be obtained. Temporary disability from six to ten weeks is the rule.

What, therefore, is the indication for operation?—the diagnosis. There is one rational treatment for a torn cartilage—its removal, and this, as soon as the diagnosis can be made. I have operated in emergency on a few cases

brought into my office or the hospital with the joint locked. If, however, there is no locking and we are still confident of the diagnosis I think it might be well to wait a few days for the subsidence of the synovial reaction. This, though, is by no means essential. The joint should be put at rest, but in my opinion external heat, manipulation, diathermy and all forms of physiotherapy are contraindicated.

A majority of the cases which were encountered were those which had been subjected to physiotherapeutic insults for weeks and sometimes months. These are the cases which bleed profusely. I have found repeatedly no necessity for ligatures. The region of the knee joint does not take kindly to the foreign protein of catgut.

After performing any series of routine operations one unconsciously drifts toward simplicity of method and economy of maneuver and manipulation. I have arrived at a standard of operation which is recommended in view of the short time obligation imposed upon the working man and the very low percentage loss motion. I have followed most of my cases back again to industry. The majority have minimal defects. Many have no defects. The higher percentage defects are due to the long delay in operations in which there has been replacement fibrosis in the quadriceps muscle preventing complete flexion and other associated pathology. This delay is not to be accredited to the operative procedure but in many instances to prolonged physiotherapy.

The incisional approach so frequently spells the success or failure of the arthrotomy that observation in these cases may be of interest. In the early series we opened the joint vertically by splitting the patella, or the long parapatellar exposure, curved or straight, but in so many cases we had difficulties that we were forced to abandon these pedigogic or teaching exposures to obtain freer postoperative mobility and a shorter period of convalescence.

A certain number of cases develop an unusual postoperative effusion. In two classical instances of my colleagues, in which nine-inch parapatellar incisions were made, postoperative intra-articular pressure ruptured the capsular and ligamentous sutures, permitting a complete external dislocation of the patella—both cases came to reoperation. Another group of cases present a postoperative subcutaneous periarticular reaction due to lack of resistance to the excessive amount of catgut required in such long incisions. This periarticular reaction subsides very slowly and greatly prolongs a convalescence. Longshoremen, demolishers, construction and cement workers and other types of labor in which the foreign element forms a very high percentage, will frequently develop a psychoneurotic attitude to the long scar and its frequent periarticular reaction which gives them adequate pretext to prolong compensation payments for a year or more. Moreover, the frequency of sensory disturbances, particularly the numbness following severed internal saphenous nerve filaments, is another pretext for prolonging disability payments.

The knee joint is therefore less exposed to surgical insult by the use of the "peep-hole" incision—one inch long, extending below and lateral to the patella, terminating at the anterior end of the semilunar attachment. After

the skin is incised the subcutaneous tissues are forced bluntly aside, the collateral ligament exposed and split in the direction of its fibers and again by blunt dissection the capsule exposed. At the lower pole of the incision are the geniculate arterial twigs which can be retracted, with a bloodless access to the joint. The one-inch capsular incision can be stretched by blunt retractors to permit visual access to all the structures of the anterior portion of the joint where practically all of the joint pathology lies.

In semilunar pathology, clinical signs will indicate whether it be a dislocation of the internal or external cartilage and the incision can be made accordingly. All pathology can be treated through the small incision except the removal of the opposite semilunar. With the cautious and gentle use of the blunt retractors there is no necessity for overlooking additional items of pathology. The teaching incisions have been abandoned as being unnecessary, exposing the knee to hazardous complications, and contributing in many cases to unstable joints. A procedure is presented and recommended, which for simplicity may be indicated by the following points in technic:

(1) Preoperative shave; green soap scrubbing, iodine, decolorized with alcohol and a sterile towel.

(2) Morphine, preliminary to spinal anesthesia, for complete muscular relaxation and vasomotor constriction.

(3) Omit the tourniquet.

(4) Iodine preparation from the toes to the upper thigh. We do not consider the operative technic of entering the knee joint with any more apprehension than a laparotomy. We omit the Lane, no touch technic, and avoid towel tricks. We believe the knee has the same biologic resistance to infection as the abdomen and will take care of the casual staphylococcus present in any operative skin incision.

(5) With this preparation not one of this series had an infectious reaction, though a few had an escape of synovial fluid into the subcutaneous tissues, another small number showed catgut irritation, and one or two cases had stitch abscesses. In no case was there a septic arthritis. As proof of the preparation there has been the primary healing.

(6) Just lateral to the patella, beginning at the anterior end of the semilunar cartilage, a vertical one-inch incision is made. This skin knife is discarded, and by blunt dissection the internal lateral ligament is exposed. This is split in the direction of its fibers and at the lower end of the split is encountered the inferior geniculate artery which is the only ligation required, and in many cases this can be retracted. The capsule is then divided and blunt fenestrated McBurney's retractors are inserted and the entire wound inspected, without traumatizing the synovial membranes.

(7) Through this opening it is possible by the proper application of blunt retraction to inspect the opposite cartilage, anterior crucial ligament, fat tabs, condyles of the femur and the semilunar cartilage.

(8) We use the standard abdominal technic, have discarded the no touch method, and do not traumatize the synovial lining.

(9) In the transverse fractures, the anterior fragment is removed *in toto* by the use of a bistoury pointed scalpel. In cases which have not been subjected to prolonged baking and diathermy there is very little vascular reaction when the margin of the cartilage is split from its attachment at the coronary ligament. Gauze packing for a moment or two is a sufficient hemostat. In the bucket-handle type the inner fragment is cut by a narrow, sharp pointed blade as far back in the intercondylar space as possible. Then the external portion is removed from the margin of the tibia as far back as possible. I have never encountered postoperative symptoms from the retracted posterior cartilage fragment.

(10) Take scrupulous care to cut off the snow capped tip of the fat tabs. This was brought home to me in one or two classical cases in which a very satisfactory removal of an internal semilunar cartilage was done and some months later it was necessary to reoperate to remove two fibrous fat tabs before a cure of symptoms could be obtained. This impresses one of the necessity of removing all the pathology of a knee in one sitting.

(11) The fat tabs are trimmed off, rarely tied. The bleeding is insignificant and stops readily on pressure.

(12) Use the gentlest intra-articular manipulation.

(13) The joint should not be closed until all bleeding points have been stopped by pressure.

(14) We protest against pouring saline or ether into the knee joint.

(15) Closure of the wound consists of the use of single No. 2 chromic, interrupted, with exact apposition of the synovial borders without eversion of the synovial membrane into the extra-articular spaces. Interrupted sutures are used, as not infrequently there is a pronounced postoperative effusion which sometimes persists for many days. If a single continuous suture be used it not infrequently absorbs or breaks and the entire capsule wound gaps open. The same may be said in repair of the internal lateral ligament, namely, the use of single, interrupted chromic No. 2 at quarter inch intervals. The repair of the subcutaneous tissue should be made by plain No. 1, either continuous or interrupted, and use of silk for skin is preferable to catgut as the latter not infrequently produces an aseptic reaction. One small square of gauze is placed over the wound and the single layer of wadding is rolled around from the midcalf to the midthigh. Around this a circular case is applied. The case is used as a buffer to prevent an undue effusion into the joint and to avoid the danger of too much tension on the sutures.

(16) The case is removed on the fourth day and the wound inspected. The sutures are removed on the seventh day and gentle passive motion begun. I do not approve of forceful, painful flexion of the leg at this time. Let the patient be his own masseur and manipulator—but keep after him! On the fourteenth day the patient routinely leaves the hospital, usually encumbered with a little excess fluid which subsides in the course of an additional two weeks. Persistent activity on the part of the patient is encour-

aged and manipulation and massage is necessary only in the case with muscle atrophy. Six to ten weeks is an average disability.

SUMMARY

(1) Early diagnostic recognition of the torn cartilage and its differentiation from other conditions.

(2) The diagnosis is the indication for operation.

(3) The contraindication of physiotherapy after injury and the tourniquet prior to operation.

(4) The employment of the small, bloodless incision and the gentle handling of the intra-articular structures.

(5) Early postoperative muscle development.

(6) The minimal scheduled defect and the short postoperative convalescence recommend the standardization of this method of treatment.

INTERNAL DERANGEMENTS OF THE KNEE *

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WHEN a patient complains that his knee slips, catches, locks or gives way, it is no longer wise to make a diagnosis of a loose meniscus, and take it out through a peep-hole incision. There are other conditions which are involved in these attacks of instability, pain and swelling which should be considered and attended to.

The stability and usefulness of the knee joint can be interfered with in more ways than one. It is better not only to make as careful a preoperative diagnosis as possible, but also to make as thorough an exploration as can be done without impairing the joint function. The synovial lining and its subjacent fat pads, the articular cartilage covering the femur, patella and tibia, the lateral and crucial ligaments must be considered as well as the meniscus on each side. In addition to these conditions, loose bodies in the joint and abnormalities in the periarticular structures should be borne in mind.

If a naked femur and a tibia are fitted together, one is impressed by the poor fit of the articular surfaces. With the menisci in place, the cup for the condyles on each side is a little deeper but it still looks pretty unstable. When the collateral and cruciate ligaments are added, it gains a good deal of rigidity. But clinically the knee is only rigid in two positions, extreme extension (the locked position) and extreme flexion. These ligaments are all lax in any other position as can be shown by the distinct amount of rotation and lateral motion which can be obtained in any normal knee if the muscles are relaxed. If it is realized that the only time, in normal use, that the knee is fully extended is when the individual stands with his weight on one leg, the importance of these ligaments in maintaining stability becomes negligible. They check excessive motion but they do not hold the knee rigid. In ordinary walking, running, lifting, sitting or in the various forms of athletic exercise, the knee is never in complete extension or complete flexion. The stability and smooth function of the normal knee depend on the supporting muscles which pass across it. Hence, the importance of maintaining the tone of these muscles when the joint becomes deranged. As the knee is flexed and extended, the point of contact between femur and tibia shifts forward and backward. Coincident with this the menisci move forward and back. This probably is due to the pressure of the approaching articular surfaces in the same way that a watermelon seed can be propelled when squeezed between thumb and finger. Unless the pressure is maintained steadily, however, they can be caught between the opposing surfaces and then become subject to crushing injuries, which split, break or loosen their attachments.

In certain parts of the knee joint, the synovial lining is firmly adherent to

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the adjacent periosteum, capsule or aponeurotic structures. Elsewhere it is separated by fat pads of varying thickness. Distal to the patella this fat pad is more marked than anywhere else and its synovial covering lies in folds with thin sharp edges which lie more or less horizontally. It is attached to the anterior part of the intercondyloid notch by a thin band called the ligamentum mucosum. These synovial folds or alar ligaments can be caught between the joint surfaces with resulting hemorrhage and laceration. With the organization of the blood clot, fibrous nodules are formed which in turn are more easily caught and again damaged. Several of these fibrous nodules may be found in the free edge, sometimes of considerable size, and may even contain bony tissue. At times these nodules are seen attached by thin pedicles and they may become detached to form one type of loose body.

Less frequently the fat pads lying elsewhere in the joint are hypertrophied with resultant folds and fringes or villi. When sufficiently pronounced, it is called villus arthritis. The term lipoma aborescens, has been used to describe an especially exaggerated type with cauliflower like mass of deep yellow or orange colored fat.

The pad lying just proximal to the patella between the quadriceps tendon and joint cavity may hang down and get between the patella and femoral surface. Similar fat tabs are found lateral to the femoral condyles. These have been seen hemorrhagic and lacerated.

There is a wide variation in the appearance of the synovial lining in these deranged knees. It may be quite normal in appearance and texture, often it is injected, frequently it is thickened, edematous, velvety and purplish in color, or it may have a deeper sepia color. In recent cases of injury, actual lacerations of the synovial lining are seen. In old cases with repeated accidents, especially when loose bodies are present, it may be brown, tough and leathery and two to five Mm. thick. Adhesions are found at times, either in the form of bands or as partial obliteration of a portion of the joint cavity. These undoubtedly give rise to pain and limitation of motion.

The articular cartilage covering the femoral and tibial condyles and the back of the patella frequently shows evidence of disease. Instead of the bluish white appearance and hard surface it may be distinctly yellow and soft. When a smooth instrument is rubbed over its surface, it feels loosened and can be thrown into little folds. The cartilage may be fissured and frayed so that finger-like processes can be lifted up. The process may go deeper and involve almost the whole depth of the cartilage and large portions may be partly detached with the formation of pedunculated flaps. The more exaggerated picture where large areas several cm. in diameter are more or less completely separated with a portion of underlying bone is less commonly seen. It is believed that only this extreme type deserves the title of osteochondritis dissecans. Chondritis seems a better term for what may be the early stages of the same condition. This condition can quite well be explained by trauma alone, without making use of the embolic theory. The milder lesions are frequently associated with an abnormal meniscus, fat tabs

and loose bodies, or they may be the only discoverable lesion. When these portions of articular cartilage become entirely separated they form a second type of loose body. A third type of loose body is seen when a portion of the condylar surface is knocked off by direct trauma. Sometimes its former site appears as a concavity in the condyle, the surface of which varies with the time elapsed since the accident. In several cases with rather recent accidents, masses of fibrin were found lying on and adherent to the synovial lining. In one case a strand was found, six cm. in length and attached only at its two ends. These easily might have become detached to form loose bodies.

Seventy-nine per cent of our cases gave a definite history of injury to the knee which usually involved side bending or rotation. It is quite logical to suppose that most meniscus cases start with such an injury which loosens their normal attachment and makes them more likely to become pinched and injured. When such knees are explored soon after the injury, it is often possible to demonstrate tears in the aponeurotic layer, in the lateral ligaments, in the synovial layer and the patellar tendon. In our last 109 cases, 18 per cent showed partial or complete tears of the anterior cruciate ligament and many of these had no instability demonstrable.

The various types of injury to the meniscus are well known. It may become detached at any point in its circumference and split in any direction, or it may only be abnormally loose. In any case it gets caught between the condylar surface and makes trouble. Cysts occur occasionally in the cartilage. We have but one suspected case which refused operation. Occasional new growths are found in the periarticular structures which may interfere with normal joint motion. We had one example of hemangioma invading the region of the knee which had extended into the alar fat pad and become injured. In a number of these cases hypertrophic lipping of the margins of the femoral or patellar articular surface was found. These irregular spurs may be smooth and rounded or may present sharp, jagged edges. The synovial membrane in contact with these projections shows the evidence of repeated irritation. Irregularities in the articular surfaces of either femoral condyle, or tibia, or the dorsal surface of the patella as a result of fracture, sometimes interfere with normal joint function.

The histories of patients with internal derangements of the knee are very similar irrespective of the condition existing in the joint. There are usually repeated attacks of what they describe as slipping, catching, giving way, or locking of the knee, usually accompanied by a sudden, sharp pain and followed by more or less joint swelling. The attacks may be slight in severity and transient in duration, relieved by shaking the leg or kicking it out straight. On the other hand, the joint may be definitely locked with inability to change the position which persists for several days. Some people are able to discover just what motions bring these attacks on and learn to avoid them. One patient is recalled who gave up, one after the other, tennis, golf, swimming and running, but when her knee locked as she turned over in bed, she

agreed to operation. In the large majority of cases, the trouble starts with a definite injury which usually involves abduction or rotation of the leg on the thigh. It is probable that in the meniscus cases, the normal attachments of this cartilage are so torn or loosened as to make it more subject to getting caught between the articular surfaces.

An accurate detailed history together with a thorough examination as to points of tenderness and abnormal mobility, and a careful palpation of the whole region of the knee joint may enable us to differentiate between some of these various forms of derangement. One's diagnostic ability, however, is usually not sufficient to avoid mistaking the main lesion, or in ruling out other associated lesions. In a large majority of cases, therefore, it would appear better surgery, when a knee is operated on for an internal derangement, that it be thoroughly explored. In the last 109 cases we have had, 27 per cent showed a single lesion; 27 per cent showed two lesions; while the remaining 46 per cent showed anywhere from three to 11 abnormal conditions in the joint; 73 per cent showed multiple lesions.

Inasmuch as the stability of the knee depends so largely on the tone of the thigh muscles, too much attention cannot be paid to as rapid a return of them to normal as possible. The best way of developing muscle and maintaining its efficiency is by active movements on the part of the patient. It seems to be a fact that any operation on the knee joint will entirely interrupt the contacts between the central nervous system and the muscles, so that for a while the patient is quite unable to contract his thigh muscles at all, and this varies from a few hours to a week or even longer. It is believed that the period can be shortened materially if the patient practices contracting his thigh muscles before operation. This voluntary control of muscular action should be resumed at the earliest possible moment after the operation, whether the joint is actually bent or not.

Although the old fear of opening knee joints has largely disappeared, the danger of infection still exists and the results of an infected knee joint are still terrifying. The experience of an ankylosis following infection makes one appreciate this. It seems wise, therefore, to exercise every precaution which lies at our disposal to prevent this tragedy. This means thorough skin preparation, complete protection of the wound from skin exposure, and a complete non-touch technic. Many men have advised a long incision with as complete an exposure of the knee joint as possible. We thoroughly agree with this recommendation, and believe this can be done without shortening the convalescence or impairing the after use of the knee. We prefer a parapatellar incision to one which divides the patella vertically. Whether the lower part of the incision returns to the midline or swings out along the joint line seems to be immaterial, but full exposure should be made.

The various pathologic conditions described should be attended to. A loose or injured meniscus should be removed. Hypertrophied fat pads, especially if they contain fibrous nodules in their margins, should be excised. If the articular cartilages are involved, whether softened, frayed, or more or less

detached, the diseased part should be cut away with a sharp gouge or other clean-cutting instrument until normal cartilage is encountered. Sharp hypertrophic spurs should be rounded off. In certain cases, a varying amount of synovial membrane requires excision and of course all foreign bodies encountered should be removed. The stump ends of torn crucial ligaments should be excised if they are apt to be caught between the opposing surfaces. We have not as yet made any attempt to repair these ligaments even when completely torn across as we have not encountered any case where this injury seemed to give any instability. The use of a tourniquet undoubtedly reduces the time of operation materially and since using this, we have had a great decrease in the number of postoperative aspirations.

The majority of our cases have been done under avertin and nitrous oxide anesthesia, with a fair proportion under spinal. As soon as the patient is out of his anesthetic he is urged by everyone who passes his bed to try and contract his thigh muscles and lift his heel off the bed. He is in a chair on the third or fourth day and walking with crutches the day after, increasing the amount of weight bearing as fast as he will. He leaves the hospital between the ninth and fourteenth day and many of them discard crutches and even a cane at the end of two weeks. The resumption of full function depends very largely on the cooperation of the patient. The time at which he resumes full use of the knee varies from one to three months.

During the period 1929–1934 inclusive, the Fracture Service at the Presbyterian Hospital has treated 596 traumatic knees. Four hundred twenty-five have been treated conservatively, 171 have been operated on. Of these, 14 were repairs of fractured patellae. The remaining 157 were operated on for internal derangement of the knee. In the first 48 a small incision was used. In the last 109 a larger incision allowed a more thorough inspection of the joint. There were 117 men and 40 women.

The various age groups were as follows:

Under 15	2	51–60	11
15–20	53	61–70	3
21–25	38	71 +	1
26–30	17	Age not stated	3
31–40	20		
41–50	9		157

In 35 cases the synovial membrane was distinctly thickened, in three it was torn, in 11 villi were present and in five adhesions were present. The articular cartilage over the femoral condyles, the patella, or tibia was diseased in 70 cases. The condyles were affected in 55, the patella in 36 and the tibia in six. The alar fat pads were pathologic in 66 cases. The medial meniscus was abnormal in 96 cases, the lateral in 15. In 12 cases the anterior cruciate ligament was completely ruptured and in eight others partially torn. Thirty-two cases showed one or more loose bodies, eight of which were definitely fragments of condylar articular cartilage. In seven cases the pathology was

not sufficient to justify the exploration. In no case was the knee completely normal.

SUMMARY

The meniscus is not the only cause of internal derangement of the knee. Many other conditions may give the same clinical picture.

The majority of these knees have more than one lesion.

It is wiser to make an incision which will allow full exploration of at least the anterior portion of the joint.

The thigh muscles are the most important structures in maintaining stability of the knee joint. Maintenance of their tone should be aimed at before operation and resumed as quickly as possible afterwards. This is best accomplished by active use.

Illustrative Case Reports

Case I.—P. F., 19 years of age. Three and one-half years before admission, the patient jumped down a short distance, kicking his heels up as he did so. Before he reached the ground, he felt a sharp, sudden pain in his right knee. After that, he was unable to put his heel to the ground in walking; that is, there was distinct limitation of extension. Operation was advised but refused, and the patient continued to have an unstable, weak knee.

Three days before admission, while climbing stairs, something snapped in his knee and he was unable to extend it beyond 130°. There were pain and tenderness along the medial aspect of his joint line. He was operated on May 25, 1932, and a "bucket-handle" meniscus was excised. The synovial lining was slightly thickened, but the articular surfaces and other joint structures were normal. He was up on the fourth day, walking on the sixth, and discharged on the eighth. He reported back five months later with a complete return of function and with no pain or disability. He stated that on the fourteenth day after his operation he pitched a full nine innings of baseball and ran bases, too, without subsequent pain or swelling. Two years and three months after his operation he is still rated as completely normal.

Case II.—S. D., 20 years of age. Ten days before his admission to the hospital, the patient slipped while working and struck the inner side of his left knee. There was immediate pain, followed soon by swelling. There was limitation of extension with tenderness along the medial aspect of the joint line. Seventy-five cc. of bloody fluid were aspirated and, on the following day, 50 cc. more. As extension was still limited after 12 days, he was admitted for operation which was carried out April 11, 1933.

The joint contained about 30 cc. of serosanguinous fluid. The medial meniscus was partly detached in front, thickened and split, the inner portion being loose and tucked under the lateral portion so that its end was presented as a rounded nub. The ligamentum mucosum and the anterior cruciate ligament were completely torn across. The meniscus and stump of the cruciate were excised and the alar pad sewed up to the front of the joint.

The patient walked with crutches on his ninth day and was discharged on the tenth. At the end of five weeks, he was playing box ball. At three and one-half months his only complaint was slight pain on the inner aspect of his joint. He went back to work in the boiler room at the end of three months. At the end of a year, there was no instability or pain. His movements are complete, but he says that after long walks or playing baseball, he has a slight sense of weakness.

Case III.—A. H., 40 years of age. Ten years before his admission to the hospital, a horse fell on his leg, which laid him up for a month. The pain, which began at that

time, increased with gradual swelling three weeks before his first admission and roentgen rays showed the presence of a loose body.

On July 10, 1931, at operation, a pedunculated, loose body was found in the intercondyloid notch, and removed through a small incision. The patient started weight bearing on the tenth day and was discharged on the twelfth. He continued to have some pain and a sense of weakness, with a varying amount of fluid in his joint.

Twenty-one months later he had to give up work because of pain and swelling. He was readmitted May 2, 1933. The knee was explored through a longer incision. There were many large hypertrophic spurs along the articular margins of the condyle and patella. The medial meniscus was eroded and the synovia was thickened, purplish and fringed, and the alar fat pad was hypertrophied. The lateral meniscus showed a dentate edge and there was a large eroded area on the femoral condyle. The spurs were removed, and the alar fat pad and lateral meniscus were excised. The eroded area on the condyle was shaved to normal tissue and the greater part of the thickened synovia was excised. The patient could lift his heel from the bed on his fourth day and was up in a chair on the eleventh, walking on the twelfth. A moderate sized hematoma was opened on the fifteenth day which healed slowly without infection, the patient being discharged on the forty-first day. Twelve weeks later his motions were 175°–90° and he was walking four or five blocks. Seven months after the operation, he reported back that he had been working for some time, being on his feet for eleven hours without difficulty.

Case IV.—J. T., 19 years. The patient stated that a year before admission he fell from a tree, landing on both knees. He was laid up for a week with a swollen, painful right knee. Soon after this he noticed a movable lump and since that time there occurred several attacks of pain and swelling with occasional locking. He said he could feel three separate loose bodies. These were evident on radiographic examination and on December 10, 1931, two loose bodies were removed through a small incision.

Ten days later the joint was again opened through a median patella splitting incision and a third loose body was removed. A large, deep, eroded area was found on the medial condyle, and the alar pad was greatly thickened with several fibrous nodules in its margin. The synovia was purple, velvety, and thickened. In addition to removing the third body, a partial synovectomy was done and the margins of the eroded areas were shaved off.

The patient was up on the eighth day, walking on the twelfth, and discharged on the twentieth. Crutches were discarded at the end of four weeks. At the end of 14 weeks he was working as a floorscraper. He reported at the end of 28 weeks with complete return of function, being able to sit on his heels and with no pain or disability. At the end of 20 months, the report is normal; there is painless motion with no disability.

Discussion

Dr. John J. Moorhead recalled having on two occasions shown before the Society a series of knee joint cases. He had, and quite recently, prepared a résumé of these which now number 244. He was almost completely in accord with what Doctor Darrach had said in respect to the methods of diagnosis, in respect to the multiplicity of lesions within the joint, and particularly as to operative treatment and postoperative management. One of the most striking demonstrations he had made was that even in the presence of marked damage to the crucial ligaments, nevertheless, function had been maintained. In a number of these cases there have been plateau fractures in which the spine of the tibia was unquestionably damaged. At Reconstruction Hospital he had not been able to pick up a case in which he could be sure there had been a crucial ligament injury. He was particularly glad to hear Doctor

Darrach say that he is in favor of, and employs, the large incision. He has apparently abandoned the median incision in which the patella was split. The mediolateral incision follows the inner margin of the patella because most lesions are on the inner side. That is a very satisfactory incision and can be made on the outer margin instead, if desired. He was likewise pleased to learn that by the use of tourniquet the postoperative effusions had been lessened. That had been his experience. He was interested, also, in Doctor Darrach's remarks as to the development of osteochondritis dissecans and particularly in hearing him say that a history of trauma can be, and often is, obtainable in these cases. He thought the speaker's emphasis on the ultra-aseptic technic most important.

Dr. Donald Gordon thought that to the majority of people who have two good knee joints, Doctor Darrach's presentation would be sufficiently interesting, but to one who has only one it is very pleasant to see the success with which knee joints can be exposed and patients quickly turned out of the hospital without the infections that were held up before us in the old days. The surgical profession should emphasize to the medical profession the importance of these so called minor pinched lesions, or whatever they might be. If they could be taught to get these cases under proper surgical care before they develop relaxation of the muscles, it would be a great step forward.

Dr. Clay Ray Murray said prompt recognition of many of these injuries to the knee joint is of the utmost importance. It is early attention to many of them which spares the joint from subsequent secondary degenerative changes. One of the chief obstacles to prompt and adequate care is the frequency of the diagnosis of traumatic synovitis with effusion. It may be almost categorically stated that accumulation of fluid in a knee joint to an appreciable amount in twelve hours or less after a trauma to a previously normal knee never represents a traumatic synovitis, but a hemarthrosis. Any diagnosis made under these circumstances must explain bleeding into the joint cavity. If this is understood there is much less likelihood of passing over derangements of the joint, and much less chance of overlooking pathology on exploration of the joint, and much less satisfaction in the use of an incision inadequate for thorough exploration.

The statement in reference to early fluid accumulation after knee joint injury, often after relatively mild indirect trauma, and hemarthrosis, and incidentally the safety of knee joint aspiration under proper technic, is supported by the results of several hundred aspirations over a period of five years without the occurrence of anything remotely resembling infection, and with, so far as I know in early cases, not a single exception to the rule that early accumulation means hemarthrosis.

Doctor Darrach said in regarding the advantage of getting these knees fairly early, I have completely shifted my point of view. I used to let them

wait until six or seven attacks, that is until the condition seriously interfered with their pleasure. I have seen a lot of those fellows since and many have had their knee joints operated on by someone else, or else the joints are creaky and slippy, or they have given up their tennis or are playing only seven holes of golf. We treat our automobiles better. If we get anything knocking in it, we get it out, and it seems to me when there is a meniscus or a bit of bone being ground up it should be gotten out. I firmly believe that many chondritic cartilages are not embolic, but just plain trauma. We all know that cartilage does not heal very well. It may be replaced by fibrous tissue. When you are satisfied that there is something wrong with a knee joint, you had best go in and attend to it. My impression is that we have had well over 500 aspirations of the knee joint and I don't believe we have had more than three yellow taps in the whole lot, which is less than 1 per cent in knee joints following trauma. They are not yellow taps, but blood, and you can't get blood unless something tears and gives way; whether it is synovial lining or bone or some part of the joint, these aspirations are bloody.

It took me a long while to come to the free wide incision—about three years ago. That is a long time to wait before profiting by your mistakes. But there are still a lot of peep-hole men.

To persuade patients to move their knees requires a good deal of team work. The patients are talked to beforehand and almost before they come out of the anesthetic. Everyone who goes by—internes, nurses, and others—tells the patient to move his knee. Some patients will do so at once; others will not make a quiver and require four or five days before beginning to contract their muscles. The sooner those muscles begin working together on their own, however, the sooner will you have a recovery. The only way is to make *them* do it. We do not put them up in plaster.

BRIEF COMMUNICATIONS AND CASE REPORTS

DUODENAL ULCER AND BANTI'S DISEASE*

JOHN E. JENNINGS, M.D.
BROOKLYN, N. Y.

CASE REPORT.—Louis S., aged 30, an Italian barber, had been treated for ulcer of the stomach for ten years and stated that he noticed tarry stools five years before that. Admitted to St. Peter's Hospital, Brooklyn, July 1, 1929, he had been vomiting blood every three to six hours for three days and had noticed several massive tarry stools. He was exsanguinated. Hemoglobin 30 per cent. Under morphine, glucose, hypodermoclysis, bed, rest and peptonized milk feeding his bleeding ceased and after a transfusion of 500 cc., a gastro-enterostomy, posterior, without clamps, was done. His recovery was uneventful and he was discharged.

He improved under liver extract and iron, doing fairly well for a few months. Then in October, 1930, he again suffered several hemorrhages with massive tarry stools, his hemoglobin again falling to 30 per cent. He returned to the hospital where, after several weeks of preparation and another preoperative transfusion, an indurated ulcer of his pyloric and postpyloric region was excised with the mucous membrane of half the antrum and pylorus; shelling this out beneath the muscular coats after the method described by Bancroft, the ulcer was removed, the duodenum and stomach closed with exclusion of the pylorus. The gastro-enterostomy was in good condition and the pathologic report of tissue removed was nonmalignant, chronic ulcer.

For eight months the patient did fairly well. Then, again, he passed several large tarry stools and was sent to the hospital for bed, rest and care. He did well and was discharged in a month, November 15, 1931.

For more than two years he was moderately well, but his hemoglobin, in spite of liver feeding, did not rise above 50 per cent. In March, 1934, he passed tarry stools once more and again entered the hospital. This time it was found that his spleen was markedly enlarged. A diagnosis of Banti's disease was made. On May 2, 1934, operation showed a normal gastro-enterostomy and a large spleen was removed. After a rather stormy convalescence, he was discharged on August 7, 1934. He has regained his strength, gained 30 pounds in weight, and is at work on a full maintenance diet (January 7, 1935). *Pathologic Report.*—Banti's Disease (Fibroadenoma of Spleen).

Comment.—The case is presented of a man who had a duodenal ulcer, with repeated hemorrhages, and splenic anemia. The splenic anemia was undoubtedly present at the beginning but its character was unrecognized. The differentiation between hemorrhage due to splenic anemia and to duodenal ulcer is very interesting.

DIAPHRAGMATIC HERNIA

DR. JOHN E. JENNINGS presented Henry A., admitted February 16, 1921; discharged March 9, 1921. In May, 1918, while in action, patient was gassed and sustained a shrapnel

* Presented before the New York Surgical Society, January 19, 1935.

wound of the left chest. Empyema followed which was drained. In August, 1919, he vomited a large amount of blood and has had repeated recurrences of hematemesis since. He has lost weight and strength. Moderate occasional pain in the epigastrium. He now vomits everything he eats. On examination—a sick man evidently dehydrated and somewhat emaciated. His chest shows a few subcrepitant râles at the right apex. A rough first sound over the precordia with a presystolic thrill. Two scars, one in the left anterior axillary line at the third interspace and another in the seventh interspace at the posterior axillary line. A movable right kidney was recognized. Otherwise his abdominal examination was negative. Radiographic examination of the gastro-intestinal tract shows a diaphragmatic hernia with pyloric end of the stomach or duodenum in the left thoracic cavity forming an almost complete obstruction. There is shot or shrapnel in the left thoracic wall posterior at the level of the fifth interspace and below. Fluoroscopic examination shows: Plain—what seems to be a gas bubble in the stomach above level of the left diaphragm. Density as of partially collapsed lung above this. With barium meal —definite diaphragmatic hernia through left dome.

Operation.—February 21, 1921.—After a transfusion of 500 cc. an incision from the tip of the ensiform downward and outward to a point just below the tip of the left twelfth rib. Fault in the diaphragm containing practically all of the lesser curvature and a considerable portion of the fundus of the stomach about three inches to the left of the midline just lateral to the pericardium. It also contained the tip of the spleen. The opening was stretched, the adherent stomach freed and pulled down and the opening closed with a double row of sutures of chromic gut. The abdomen was closed without drain. His recovery was uneventful.

Follow up a year later showed him well and symptom free. Sometime in 1925 he began to have symptoms of indigestion—distress after eating, with nausea and occasional vomiting. He was told he had an ulcer and put on a diet. He noticed tarry stools several months ago, has lost flesh and strength, and on October 27, 1927, vomited what he says was a large amount of blood. He was again admitted to the Brooklyn Hospital on December 8, 1927. Hemoglobin 60 per cent. Red blood cells 4,800,000. Radiographic examination showed: The proximal three inches of stomach within the left chest. At the point where the stomach passes through the diaphragm there is a definite band like a narrowing of the lumen so that it measures only about an inch. Meal passes readily into the small intestine.

Second Operation.—On February 21, 1928, an incision was made removing the old scar and separating the adhesions between the stomach, the great omentum and the anterior abdominal wall. The opening in the diaphragm was found just to the left of the spine and well posterior, the aorta behind, the heart in front, the esophagus just to the inner side. It was a recurrence through the median extremity of the sutured hernia of seven years before. The opening would admit two fingers but not three. It was surrounded by a fibrous ring. The stomach was firmly adherent to the pleura and lung. An attempt to free it was begun but stopped because of hemorrhage. The ring was then cut with a probe-pointed bistoury outward toward the chest wall and the opening enlarged to admit the hand, thus freeing the hour-glass constriction of the stomach. The abdomen was closed without drainage. His convalescence was without incident.

In November, 1929, he was readmitted for hemoptysis, his gastric symptoms having been relieved since the operation eighteen months previous. This was believed to be due to an abscess of the left lower lobe of the lung where a radiogram revealed an area of thickening of lung or pleura. The irregular shadow of a shrapnel fragment was thought to lie within this area. He had no evidence of tubercular involvement. Rest in bed with postural drainage relieved his cough and hemoptysis. He did not desire operative treatment and was allowed to go home. He has been well and able to work for six years, and is offered as a case of gastric hemorrhage with diaphragmatic hernia,

treated for some time as an ulcer of the stomach—operated upon with recovery. There was a recurrence of hernia and again an erroneous diagnosis of ulcer. He was operated upon and the obstruction was relieved by section of the diaphragm with recovery. Convalescence was complicated by a foreign body abscess of left lung.

HIRSUTE VIRILISM

Dr. John E. Jennings presented H. R., female, 27; single; complaining of obesity, hirsutism, amenorrhea. Her father died of cancer. Her mother was psychopathic—melancholia. She has been obese since the age of 15. The obesity has been progressive; her weight is now 180. Until five years ago she had scant hair distribution over her arms, legs, and a little at the lower end of the spine. Within these five years hair has grown much thicker and now covers the trunk, front and back, parts of face, and all the extremities. Her periods began at 18 and have occurred about once a year, lasting three days with scant flow.

A short, heavy young woman with a round moon face. She has hair on her chin, both cheeks and upper lip. There are many fine punctate scars from the electrolysis over the lower half of her face. Obesity most marked in upper half of body including her face, back pads and girdle fat. Thick hair over sternum. Male distribution over abdomen, back and extremities. There is marked hypertrophy of the clitoris which is four times its normal size. The nymphae are barely present. On rectal examination a small uterus can be made out. There are no pelvic masses palpable. Otherwise physical examination is negative. Blood and urine examination normal. Basal metabolic rate minus 12. Her eye grounds and visual fields are normal. Roentgen ray examination of skull shows a small sella turcica. The clinoid processes are in close approximation with the ends, almost in apposition. There is no evidence of necrosis or erosion. It was decided to explore the adrenals for the presence of a cortical neoplasm, or, failing this, for diffuse hyperplasia.

Operation.—On November 2, 1934, under spinal anesthesia, an incision was made over the course of the eleventh right rib which, with the twelfth right, was widely retracted. The kidney exposed and drawn down with the suprarenal capsule. This appeared large and diffusely thickened but with no localized induration or tumefaction. It was considered a diffuse hyperplasia and the wound closed. The immediate postoperative course was stormy. The first day her temperature rose to 105.8°, respiration 40, pulse 156. The second day T 103.8°, P 136, R 36, gradually reaching normal in four days. She had received interrennin b.i.d. before operation and this was continued for three days after operation, with 1,000 cc. 5 per cent glucose in clyses t.i.d. The wound healed *per primam.*

On December 4, 1934, under spinal anesthesia, an incision, slightly lower than the previous operation on the right, was made following the course of the twelfth rib on the left, from the angle to two inches in front of its tip. The muscles were cut and the twelfth rib removed subperiosteally from its tip to the angle. The kidney was freed from its fatty capsule and drawn down with the suprarenal. The anterior face of the suprarenal was dissected free and the kidney separated from its posterior surface. Ligatures cast about the superior and inferior poles, cut and ligature thrown about the median blood supply and the gland removed. It was large and firm with no localized tumefaction. The postoperative reaction was very mild in comparison with that following the previous operation. She received interrennin, glucose and sedatives as before. She was discharged December 20, 1934.

Pathologic Examination.—A report, of the tissue removed, by Doctor Goldzieher, to whom I am indebted for the privilege of seeing this case, showed the cortex of the adrenal definitely enlarged. Several distinct layers can be recognized. Outwards, the glomerular and trabecular zones stand out by their increased lipoid load. The inner-

most part of the trabecular layer and the reticular zone are chiefly responsible for the enlargement of the cortex. They do not contain any visible lipoids. The cytoplasm of their cells stains intensely with eosin. This hyperplastic zone stands out by its intensive stain so much that it becomes visible to the naked eye. There is also a substantial ingrowth of the cortical tissue towards the center occupying the territory of the medulla. The latter consists mainly of scattered islands of chromaffin imbedded in the hyperplastic cortical growth. The latter consists mostly of darkly stained cells and only occasional islands of lipoid bearing elements. The chromaffin cells are densely packed and form syncytial complexes with several nuclei. The large veins within the central portion of the gland show fairly bulky musculature which, in some veins, is definitely hyperplastic. *Diagnosis.*—Cortical hyperplasia restricted to the inner layers, typical of the hyperfunctioning cortex; substitution of the medulla by cortical tissue and hyperplasia of the remaining medullary tissue; incipient hypertrophy of the venous musculature.

It is as yet too soon to form any opinion as to the effect if any, of this operation. The patient still retains her fat, her hair and her amenorrhea.

Dr. M. A. Goldzieher (by invitation) said that surgical conditions of the adrenals have been recognized clinically only in recent times. Previously they belonged to the pathologist only, but recent advances in endocrinology have enabled us to diagnose some of these conditions in vivo. Tumors of the adrenal glands, particularly of the cortex, have been operated on before and are known to have produced symptomatology of tumor nature as well as of the endocrine type. It was not known until quite recently, however, that simple hyperplastic enlargement of the adrenal cortex is also capable of causing symptoms directly due to hormonal effects that could be remedied by surgical methods. The case presented by Doctor Jennings attempts to illustrate that particular type of case.

What are the grounds on which we stand when we claim that the mere, and sometimes only moderate, enlargement of the adrenal cortex is capable of producing symptoms such as were present in this and other cases? What is the basis by which we can differentiate whether we are dealing with primary adrenal disease or merely with a secondary symptom complex due to hyperactivity of some other endocrine gland such as the pituitary? Among the hormone effects of the adrenal cortex, so far, only three are definitely known: (1) The life preserving effect of the adrenal cortical hormone, (2) The effect, as shown experimentally and clinically, that induces a deposit of fatty substances in the body thereby increasing weight, and (3) the action of the adrenal cortex upon the gonads, which varies according to the age and sex of the individual.

We have every reason to believe, both on the basis of clinical observation and animal experimentation, that an excess of cortical hormone or of one of the cortical hormones, if you prefer, is capable of producing obesity of a peculiar type, which, in our personal clinical experience, is characterized by a remarkable predilection for certain parts of the body. It leaves the lower extremities and forearms free and presents itself mainly as a diffuse trunk obesity with heavy neck and a full moon face.

It seems to be generally recognized that pathologic enlargement of the

adrenal cortex during embryonal life is intimately related to the development of pseudohermaphroditism. Enlargement of the adrenal cortex either of neoplastic or of diffuse hyperplastic type has been observed in children, particularly in the female child with the clinical picture of precocious puberty. In adult females it has been found in a fairly large number of cases characterized by obesity and menstrual disorders, while the syndrome apparently does not occur in the male. Another sign that always occurs in these cases is the appearance of hair of the masculine type over the body and particularly in the face. Male hair distribution or the phenomenon of hair in the face is not unusual, of course, in the endocrinopathies and could not be considered as a pathognomonic sign; however, the adrenal type of hirsutism is rather characteristic. I can look back upon many years of experience in this field from the time when we observed adrenal changes only postmortem and diagnosed adrenal cortical enlargement or adenoma before we opened up the body by a peculiar type of hirsutism, namely, the coarse black hair limited to the chin and the inframandibular region. The side of the face and the upper lip do not evenly share in the facial hairiness in contrast to the hirsutism in the pituitary type, in which type the hair is distributed primarily on the cheeks and upper lip and is soft in the beginning, before cosmetic procedures are resorted to.

The case Doctor Jennings has presented showed a full moon face and obesity of the adrenal type; the hairiness of the face and body was similar to that noticed postmortem in so many cases of adrenal hyperplasia; and, finally, on endocrine examination, the patient did not show any of the signs which we consider characteristic of pituitary disease. The left adrenal gland presented, after removal, a very remarkable kind of anatomic lesion, that I have seen only in these clinical types, namely, an enlargement of the intermediary zone and a content mainly of reticularis and the inner part of the fascicularis. This zone is not only tremendously enlarged, but it is stained differently from the rest of the adrenal cortex: it stands out as a dark reddish band, a lesion not known in any other human condition but very well known in animal experimentation. It has been described by investigators in England as zone X of the adrenal cortex and is considered to be a sign of sexual immaturity in the female animal.

PARTIAL GASTRECTOMY FOR BLEEDING DUODENAL ULCER*

RICHARD LEWISOHN, M.D.

NEW YORK, N. Y.

CASE REPORT.—A male, 56 years old, who was admitted to Mount Sinai Hospital on September 27, 1934, with the following history: Six years ago he began to suffer from epigastric pain which came on after meals and was relieved by food. He was put on a fairly strict diet and his symptoms became less severe until a few weeks before his admission. At that time although radiographic examinations were negative, a diagnosis of duodenal ulcer was made. Rehfuss test meal showed free acid 75, total acidity 115.

* Presented before the New York Surgical Society, January 9, 1935.

One day previous to his admission to Mount Sinai Hospital he suddenly vomited a large amount of bright red blood and he noticed blood in his stools. His blood pressure on admission was 90/50 and his hemoglobin was 50 per cent with 3,000,000 red blood cells. During the first few days after his admission his symptoms were not alarming. He was given glucose solution intravenously and during the next two weeks received a number of subcutaneous infusions. It was hoped that the patient would gradually recover from his hemorrhage and be strong enough for another radiographic examination. On October 22, about three and a half weeks after his admission, he went into a mild collapse from which he rallied rather rapidly. In view of the fact that surgical interference was not contemplated at that time he was transferred to the Medical Service for further observation and treatment. Two days after his transfer, the symptoms became worse. His hemoglobin suddenly dropped to 20 per cent and his blood pressure was 112/70. However, in spite of repeated citrate transfusions his blood pressure continued to fall to 70/36 and his hemoglobin to 25 per cent. The patient was evidently losing the blood as fast as it was put in by transfusion. Despite careful diet and milk drip there seemed to be no tendency for the ulcer to heal. Since his transfer to the Medical Service he had bled constantly and had at least three episodes of massive hemorrhage. In spite of the transfusion of 2,300 cc. of blood (given in four transfusions) his hemoglobin was 24 per cent. It was felt that conservative attempts to cure this ulcer had been exhausted and that in spite of his low hemoglobin surgical interference was indicated in an attempt to save this man's life. For this reason he was transferred back to the Surgical Service and an emergency partial gastrectomy for bleeding duodenal ulcer was performed on October 30.

Under general anesthesia a midline incision was made between the ensiform process and the umbilicus. A duodenal ulcer was found at the superior and posterior wall of the duodenum just below the pylorus. The stomach was divided just above the reentrant angle in typical fashion after the gastrocolic ligament had been ligated. The stomach was then pulled over toward the right and the pancreas with the duodenal ulcer attached to it was exposed. The duodenum was then freed from its adhesions posteriorly. During this process the duodenal wall tore. The ulcer base was formed by the head of the pancreas. It showed a marked infiltration and was about the size of a fingernail. After the duodenum had been freed sufficiently, three tiers of layer suture were applied to the duodenum. The lumen of the duodenum as it presented itself was comparatively small, hardly admitting the little finger. Catgut was used for the first and second layers and Pagenstecher for the third layer, thus extraperitonealizing the duodenal stump. The patient's pulse by this time was 150 and it was deemed advisable to perform a Weir button gastro-enterostomy in order to expedite the operation. A small tube was placed to the duodenal stump. During the operation an intravenous saline infusion was given.

The patient received a transfusion immediately after his return to the ward. His blood pressure on the day following the operation had risen to 135/60 and his hemoglobin had gone up to 39 per cent. The patient made an uneventful recovery and was discharged from the hospital on December 11, 1934. Hemoglobin 54 per cent. The button was passed November 12.

Roentgen ray examination December 28, 1934, showed a normally functioning stoma with rapid emptying time. A postoperative Rehfuss showed free acidity 18, total acidity 30. Hemoglobin 65 per cent.

Doctor Lewisohn stated that contrary to the general opinion the mortality from bleeding ulcers is high. Undoubtedly a large number of gastric hemorrhages stop spontaneously. However, when conservatism fails, radical surgery (partial gastrectomy) presents the only reasonable method of approach. Gastro-enterostomy is an absolutely futile operation in bleeding gastroduodenal ulcers. This patient was shown in order to demonstrate that the major operation of gastric resection may be performed successfully in a patient with a hemoglobin of 24 per cent.

Annals of Surgery
July, 1935

VALVULAR PNEUMOPERITONEUM

COMPLICATING MUCOCELLULAR CARCINOMA OF THE STOMACH

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FROM THE DETROIT RECEIVING HOSPITAL AND THE COLLEGE OF MEDICINE OF WAYNE UNIVERSITY

THE usual result of the rupture of a hollow abdominal viscus is a general peritonitis. Very occasionally a spontaneous valve-like closure occurs, which prevents the free extravasation of fluid into the peritoneal cavity but permits the escape of air. The resulting clinical picture is that of an increasing abdominal distention without peritonitis or ileus. Fluoroscopic examination in such cases shows large quantities of free air beneath the diaphragm and thus reveals the cause of the distension.

In 1932 Singer[1] collected 24 cases of this type, all from foreign literature, and reported four of his own under the title of "Valvular Pneumoperitoneum." In two of the latter the diagnosis was made prior to fluoroscopy by the characteristic clinical findings.

A case was recently observed of gastric carcinoma with spontaneous perforation leading to pneumoperitoneum without appreciable peritonitis. The valve-like mechanism which permitted air but not fluid to escape from the stomach was demonstrated at autopsy.

CASE REPORT

A female, aged 45, was admitted to the Receiving Hospital, Detroit, October 9, 1934.

Chief Complaint.—Dysphagia; abdominal distention; weight loss.

Present Illness.—In January, 1934, the patient began to have difficulty in swallowing solid food, which seemed to lodge at a point opposite the xiphoid process, causing a choking sensation, but provoking no pain. As a consequence she restricted her diet, in the main, to liquids. At times even these seemed to be blocked on their way to the stomach. She had noticed fulness after eating for some months, which she attributed to gas, despite the rarity of belching. There was no appreciable distention until the week prior to entry when the abdomen progressively increased in size. There was some discomfort attributable to the distention, but never any severe abdominal pain. The appetite was fairly good. There was no history of nausea or vomiting. The bowel movements were fairly regular throughout the illness. The patient lost a total of 70 pounds in weight and became progressively weaker. There were no cardio-respiratory nor urinary symptoms.

Physical Examination.—There was marked tenderness upon pressure over the left tenth rib in the midaxillary line, but no crepitus nor deformity. The percussion note was tympanitic over the entire liver area. There were diminished breath and voice sounds with tactile fremitus at both bases posteriorly, but no râles nor changes in percussion note. The heart was negative. Blood pressure 110/70. The abdomen was symmetrically distended and barrel shaped. The panniculus was very thin. There was slight bulging with flatness in the flanks, shifting with change in position, but no fluid wave was obtained. The remainder of the abdomen was tympanitic. There was no tenderness nor rigidity. The spleen and liver were not felt. There was a firm, slightly tender, irregular mass in the midline, arising from the pelvis and extending four finger breadths above the symphysis. On vaginal examination this appeared to be a sphere about 12 to 14 cm. in diameter. Although in the midline, the mass was freely movable to the left for

a distance of four cm. A nodule three cm. in diameter was felt in the right adnexal region. Both masses seemed to be distinct from the uterus which was small and was displaced posteriorly.

Laboratory Reports—Urine, negative. Sahli Hb 8.8 grams; R.B.C. 3,600,000; W.B.C. 6,000; N.F.N. 9 per cent; F.N. 62 per cent; Eosinophiles 1 per cent; Lymphocytes 28 per cent. Kline negative. Stools showed a consistent trace of occult blood. Six sputa were negative for tubercle bacilli.

Roentgenogram of the chest showed peribronchial infiltration at the left base and in the middle and lower right lobes with a small amount of fluid in the interlobar fissure. There was an old healed tuberculous focus in the second interspace on the right. Beneath the diaphragm there was a large amount of air, causing an upward displacement (Fig. 1). The diaphragm moved fairly freely. Complete gastro-intestinal series showed no barium

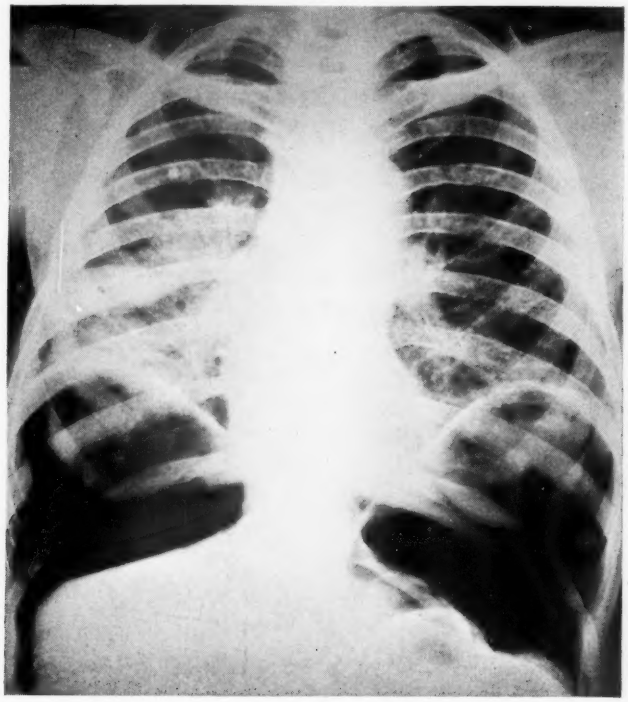

FIG. 1.—Radiogram of chest showing large amount of air beneath the diaphragm and peribronchial infiltration due to pulmonary metastases.

escaping from any part of the tract. The only positive findings were a slight delay in emptying of the esophagus and a slight irregularity at the cardiac end of the stomach. These findings were mistakenly attributed to positive pressure from the pneumoperitoneum.

Course in Hospital.—The temperature was, for the most part, normal but rose to between 99 and 100 on four occasions. The pulse ranged between 70 and 120, averaging 90. On October 15, 150 cc. of slightly cloudy yellowish-green fluid were removed from the abdomen. The ascitic fluid showed a specific gravity of 1.015, a three plus albumin and contained 1,440 W.B.C. per cubic Mm., 95 per cent of which were polymorphonuclears. No organisms were found in the smear of the sediment and there was no growth after three days' culture. A specimen of gas was obtained from the peritoneum, which on analysis showed 7 per cent carbon dioxide, 2 per cent oxygen and 91 per cent nitrogen.

Operation.—October 27, 1934, under spinal anesthesia. Upon opening the abdomen a large amount of odorless gas escaped and the distention disappeared. There was about 500 cc. of a serosanguinous fluid in the peritoneal cavity, but no definite inflammatory reaction in the peritoneum. Bilateral solid tumors of the ovaries were found and removed. The upper abdomen was explored by palpation and by means of a Cameron light, but no further pathology was noted. The patient did not react well to the operation and expired a few hours later.

Pathologic Diagnosis.—The gross and microscopic appearance of both ovaries was characteristic of mucocellular carcinoma (Krukenberg tumor).

Autopsy.—Thoracic Cavity.—Scattered diffusely throughout both lung fields were fine white nodules measuring from one to three Mm. in diameter. On microscopic examination these proved to be areas of metastatic new growth.

Abdominal Cavity.—Upon opening the abdomen a considerable quantity of odorless gas rushed out. There was about 300 cc. of nonpurulent sanguinous fluid in the abdominal cavity. There was no evidence of peritoneal reaction. The omentum was firmly attached to the cardia of the stomach. Separation of the adhesions revealed a dense white mass of new growth tissue which encircled the cardiac orifice and extended horizontally across the anterior aspect of the stomach in a finger-like projection. At the tip of this process and uncovered by omentum, there was a perforation five Mm. in diameter.

Microscopic examination of the stomach wall showed the typical signet ring, mucin containing cells characteristic of mucocellular carcinoma.

FIG. 2. — Cross-section of stomach wall, showing perforation and valve action of mucosal fold. Solid black indicates carcinomatous infiltration. Shaded section indicates normal stomach.

Comment.—When the excised stomach was forcibly distended with water, no fluid passed through the perforation. However, when the stomach was artificially inflated, air escaped readily.

The valve-like mechanism which prevented the extravasation of fluid but permitted the escape of air through the perforation during life and at the autopsy was revealed when the stomach was opened. Projecting into the lumen of the stomach from a point five Mm. below the perforation (Fig. 2) there was a fold of mucosa two cm. in length and five Mm. in thickness. The fold was movable at its base in the manner of a hinge. Fluid filling the stomach from its most dependent portion (as occurs physiologically) forced the mucosal flap upward against the stomach wall so as to cover the perforation. A sufficiently tight closure was thus obtained so that no water escaped when the fluid level rose higher.

Air, on the other hand, collected in the fundus and filled the stomach from above downwards. The mucosal fold was thus forced downwards away from the perforation, leaving no obstacle to the escape of air. The position of the perforation high up on the anterior wall of the stomach was probably an additional factor which favored the escape of air and hindered the egress of fluid.

SUMMARY

A case of mucocellular carcinoma of the stomach is reported, in which

spontaneous perforation occurred leading to pneumoperitoneum without peritonitis. The valve-like mechanism which permitted the escape of air but prevented the free extravasation of fluid into the peritoneal cavity was demonstrated at autopsy.

REFERENCE

[1] Singer, H. A. Valvular Pneumoperitoneum. J.A.M.A., vol. 99, p. 2177, 1932.

STAB WOUND OF THE HEART

REPORT OF A CASE

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THE following case is reported not only because of the relative infrequency of this type of injury but also because of several unusual associated conditions.

CASE REPORT.—Horace D., a 15-year-old colored boy, was admitted to the Saint Philip Hospital July 26, 1934. During an altercation he was stabbed in the left chest with a large pocket knife. On admission the patient was unconscious and profoundly shocked. The skin was moist and cool, the pulse imperceptible and the blood pressure could not be obtained. Respiration was labored and sternomastoid in type. Blood escaped freely from a sucking wound four cm. in length situated about three cm. to the left of the sternum and immediately over the fourth and fifth costal cartilages which had been completely divided (Fig. 1). The entire left chest was flat to percussion, breath sounds could not be heard and the area of cardiac dulness was markedly shifted to the right. The veins of the neck were not dilated. The heart sounds, though feeble, could be distinctly heard; the rate was about 150 to the minute. A snug dressing checked the external bleeding, the foot of the bed was elevated, 45 mg. of ephedrin were injected subcutaneously and an intravenous injection of normal saline started. The condition of the patient improved immediately; the radial pulse could be palpated and the systolic blood pressure rose to 60 Mm. Hg. The external bleeding increasing, the edges of the wound were separated and as the left pleural cavity was filled with blood a gauze pack was inserted between the severed cartilages of the fourth and fifth ribs to check internal bleeding from the margins of the wound. While this was being done the boy regained consciousness, became combative and had to be restrained. The location of the wound, the massive hemothorax, and the clearness of the heart sounds suggested an intrapleural hemorrhage from a severed internal mammary artery instead of an injury to the heart, which was suspected when the patient was first seen.

Operation.—The intravenous infusion was continued as the patient was moved to the operating room, and the blood pressure gradually rose from 70/40 to 90/48. The operation was begun under local anesthesia 50 minutes after the injury. The incision resulting from the stab wound was extended upward parallel to the sternum and downward and outward in the direction of the left costal margin. The gauze pack was removed, and the pleural cavity was opened under nitrous oxide-oxygen anesthesia. The third and fifth intercostal spaces were incised laterally and the severed fourth and fifth costal cartilages were reflected outward upon the costochondral junctions as a hinge. This permitted an inspection of the left pleural cavity through an opening

about five cm. square. A large amount of blood was aspirated from the pleural cavity and it was then found that the bleeding came from a rent in the pericardium about two cm. in length. The pericardial sac was opened widely and the heart was drawn up into

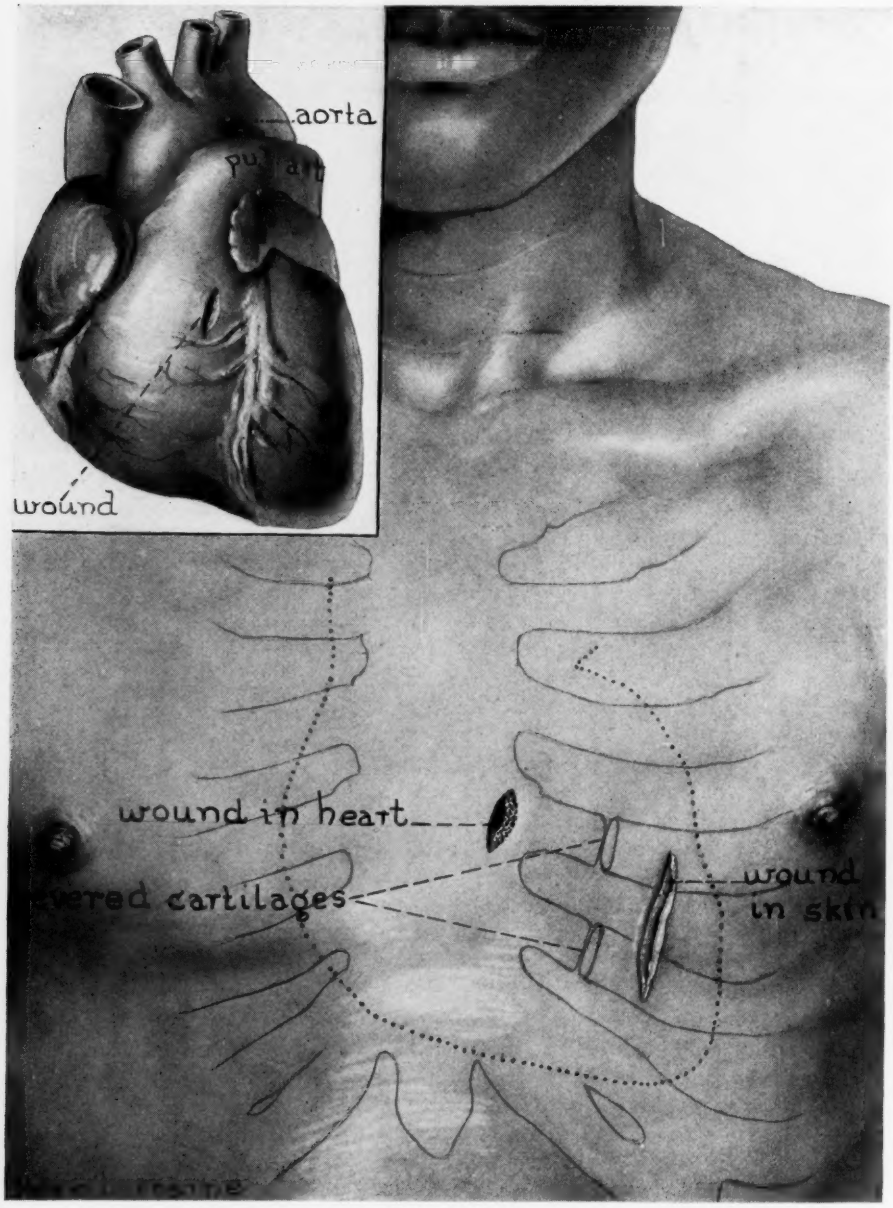

FIG. 1.—The obliquity of the wound in the skin, costal cartilages and heart is indicated in the larger drawing. The insert shows the relative size and position of the wound in the right ventricle.

view exposing a wound of the right ventricle about one and a half cm. in length. This was situated one cm. from the left coronary artery and about two cm. from the base of the pulmonary artery. The heart appeared small and anemic. A traction suture was

placed in the apex of the heart and a finger inserted in the wound checked the bleeding until the defect could be sutured. Because of the location of the thoracotomy in the left chest, and the shift of the mediastinum to the right, considerable tension was placed on the base of the heart whenever this organ was brought up into the wound. This resulted in such feeble and irregular heart action that it was necessary to replace the heart in the pericardial sac between each suture so that it could regain its regular though rapid rhythm. Four chromic catgut sutures closed the defect. The posterior surface of the heart was exposed but there was no wound of exit. The condition of the patient at this time was distinctly unfavorable. The blood pressure rapidly fell to 65/50 and the pulse could not be palpated. The head of the table was lowered and the intravenous fluids increased. The rent in the pericardium was closed except for a small opening at the lower angle for drainage. The costal cartilages were replaced and the

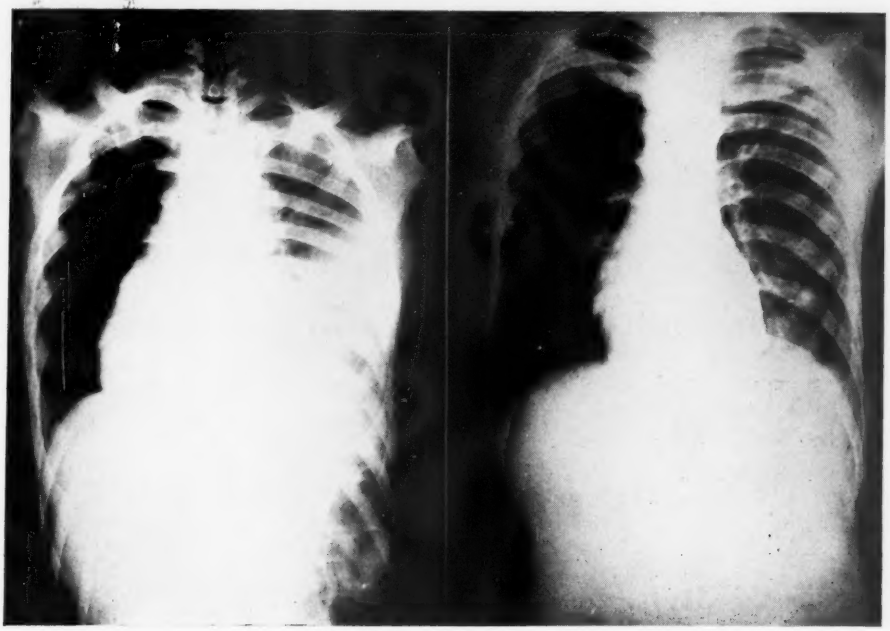

FIG. 2.—Roentgenogram of the chest one week after operation showing considerable displacement of the heart to the right and fluid in the left pleural cavity.

FIG. 3.—Roentgenogram of the chest six weeks after operation showing almost complete return to normal of heart and lungs.

chest wall was closed while the anesthetist applied positive pressure to expand the lung. Immediately after the conclusion of the operation the face and neck of the patient suddenly became edematous. The swelling of the eyelids was so excessive that the sclera could not be demonstrated. The head was raised, a transfusion of 550 cc. of blood was given with an immediate improvement in the condition of the patient, the edema rapidly subsiding.

An electrocardiogram made one hour after the operation was negative except for a sinus tachycardia of 150 (Fig. 4).

Postoperative Course.—July 27, 1934. On the day after operation the temperature was 103°; pulse 120; and respiration 40. The blood pressure was 100/50. The patient was delirious. The entire abdomen was tender and rigid. Liver dulness was present at the costal margin. There was no evidence of free fluid in the abdominal cavity. A transfusion of 400 cc. of whole blood was given. The heart was markedly displaced to

the right. The following day the temperature was 104°; pulse 130; and respiration 40. A loud to-and-fro friction rub synchronous with the heart was heard over the precordium. A large amount of air and 300 cc. of bloody fluid were withdrawn from the left pleural cavity. The tenderness and muscle spasm of the abdomen continued.

On July 29 following a third transfusion of 400 cc. of whole blood the temperature rose to 105.2°; pulse 140; and respiration 34. The patient continued irrational. An electrocardiogram showed evidence of definite myocardial damage similar to that seen in coronary occlusion (Fig. 4). Tenderness of the abdomen persisted. The following

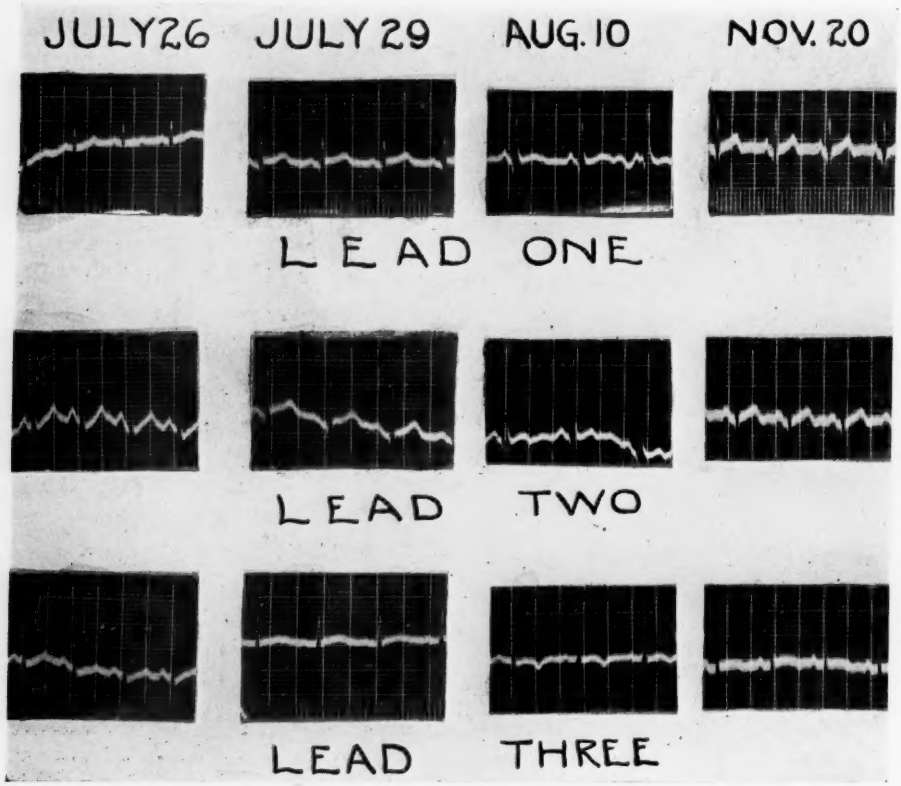

FIG. 4.—July 26.—One hour after operation. Sinus tachycardia, rate 150. Remarks: There is no definite evidence of myocardial damage. July 29.—Three days after operation. Sinus tachycardia, rate 136. Lead 1. Slightly high take off S-T interval. Lead 2. Slightly high take off S-T interval. Lead 3. Low T-wave. Remarks: The S-T phase is definitely above the base line in Leads 1 and 2; the T-waves are upright in all leads. August 10.—Fifteen days after operation. Regular sinus rhythm, rate 100. Lead 1. Slight slurring of Q.R.S., with low T-wave. Lead 2. Slight slurring of Q.R.S. Inverted T-wave. Lead 3. Slight humping of S-T interval. Inverted T-wave. Remarks: The increased upward curve in the S-T phase and the inversion of the T-waves in Leads 2 and 3 is suggestive of the electrocardiographic findings in coronary occlusion. November 20.—One hundred and seventeen days after operation. Sinus tachycardia, rate 136. Remarks: The rapid pulse rate was due to excitement. All electrocardiographic evidence of myocardial damage has disappeared. (Electrocardiograms read by Drs. P. D. Camp and Kinloch Nelson.)

day the temperature fell to 101°; pulse 100; and respiration 30. The general condition was much improved; the patient was rational for the first time since admission. He had no recollection of happenings on the day of the injury. The abdominal rigidity persisted but the tenderness was less marked.

On August 2, the temperature was 100°; pulse 110; and the respirations rapid and labored. Five hundred and fifty cc. of bloody fluid were withdrawn from the left pleural cavity with immediate improvement. A roentgen ray showed considerable displacement

of the heart to the right and the left pleural cavity contained a small amount of fluid (Fig 2). By August 9 the temperature had fallen to 98°; pulse 90; and respiration 22. The friction rub had disappeared; the heart sounds were distinctly heard and of good quality although an electrocardiogram continued to show evidence of myocardial damage (Fig. 4). There was less displacement of the heart to the right. Examination of the abdomen was entirely negative.

An uncomplicated convalescence followed and on September 11 the patient was discharged from the hospital in good condition 47 days after operation. His hospital stay had been prolonged for three weeks as a safeguard against too early activity following his return home. A roentgen ray examination showed some lack of aeration in the left lung with a slight cardiac displacement (Fig. 3). The patient showed no ill effects from his recent injury. Heart sounds were of good quality and examination of the lungs was negative to percussion and auscultation. Electrocardiogram negative. The incision was entirely healed (Fig. 5.)

Comment.—This patient did not present the classical signs and symptoms of a wound of the heart. Due to the large opening in the pericardium, which permitted the blood to escape freely into the pleural cavity, tamponage did not occur, and shock and hemorrhage into the left chest were the outstanding preoperative findings. Had the true nature of the injury been recognized before operation a more medial approach would have facilitated the operation.

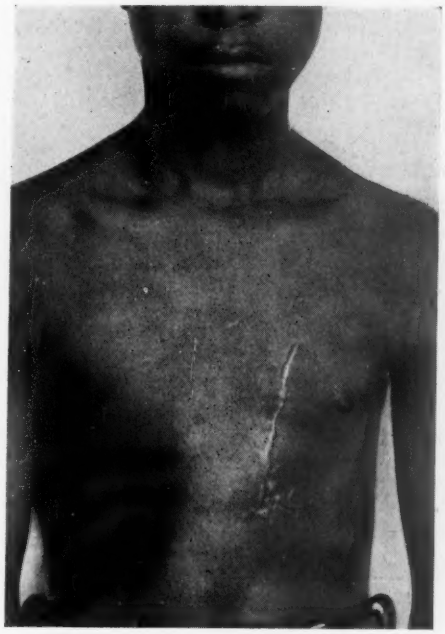

FIG. 5.—Photograph of patient, 46 days after operation. The wound is completely healed and the heart and lungs are normal to physical examination.

The sudden edema of the face and neck at the end of the operation was probably due to several factors. The patient was operated upon in the Trendelenberg position and it was thought that the large amount of normal saline injected intravenously diluted the diminished serum protein of the blood to such a degree that the fluid escaped into the tissues in the most dependent portion of the body. The edema disappeared rapidly following elevation of the head and a blood transfusion.

The unexplained and disquieting abdominal symptoms which persisted for ten days following the injury probably were referred from the pericardium as there was no evidence of intra-abdominal injury and the friction rub and abdominal tenderness disappeared simultaneously.

A case of stab wound of the right ventricle with operation and recovery has been presented. This is the fifth heart wound successfully treated at

the Medical College of Virginia Hospitals during the past four years. The first four cases were operated upon and reported by Dr. I. A. Bigger,[1] to whom I am indebted for the privilege of operating upon this patient.

REFERENCE

[1] Bigger, I. A., and Porter, William B.: Wounds of the Heart. Inter. Clin., vol. 1, Ser. 44, pp. 133–159, 1934.

HERNIA INTO UMBILICAL CORD

METHOD OF RECONSTRUCTION OF THE UMBILICUS

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IN EARLY embryonal life, before closure of the abdominal wall, the intestines are located in the umbilical coelom, outside of the abdominal cavity; at the beginning of the third month of intra-uterine life the viscera gradually recede into the abdominal cavity due to the mutual approach and ultimate merging of the visceral plates from both sides. Simultaneously, the broad communication between the intestines and the vitelline membranes is reduced and finally obliterated. Occasionally this process is defective and the closure of the abdominal wall fails to be completed; a portion of the abdominal contents remaining outside of the peritoneal cavity, within the umbilical cord, which is improperly called congenital umbilical hernia or hernia of the umbilical cord. Malgaigne suggested that this term is inappropriate for we are not dealing with viscera escaped from the abdominal cavity but with viscera which have never entered it. The term "hernia" is also grossly inaccurate in this respect, that the protrusion is not covered by the peritoneal sac in the strict sense of the word. "Eventration into umbilical cord" would be a more correct description of such formation but the term "congenital umbilical hernia" or "hernia of the umbilical cord" has been sanctioned by common use.

Arbitrarily such herniae may be divided into three groups: (1) The gap at the umbilicus is small and does not cause a marked distention of the umbilical cord. (2) The gap is moderate in size and allows formation of a visible sac. (3) The closure of the abdominal wall is grossly incomplete, leaving a fissure. In the first group a conservative treatment consisting of a prolonged application of pads will usually effect a cure. The third group requires extensive plastic surgery which cannot always be accomplished in one stage. The literature on the treatment of the second group is very scanty, the remarks usually being confined to the statement that after reduction of the hernial contents the opening is closed. An observation of a case belonging

to the second group in a newborn girl confronted the author with the problem of obtaining not only good anatomic but also cosmetic result.

CASE REPORT

CASE REPORT.—A newborn girl was the second child; after its normal delivery in St. Elizabeth Hospital, January 22, 1934, a globular dilatation of the cord was noticed at its fetal end. A cutaneous umbilicus, also called cutis navel or skin navel, was present, *i.e.*, the skin was covering the attachment of the cord, rising to form a cuff one cm. high. The globular formation occupied a portion of the cord starting 2.5 cm. and ending 8.5 cm. from the umbilicus; in other words, it had a diameter of 6 cm.; its covering consisted of a translucent and in places transparent membrane, through which loops of intestines could easily be distinguished. The rest of the cord as well as the placenta revealed no pathology. As there were no signs of obstruction and the infant was apparently exhausted by the rather long delivery, it was deemed advisable to ligate the cord distal to the hernia, apply an alcohol dressing and postpone the operation till the next morning. Sixteen hours after delivery of the infant, the hernia was repaired under local anesthesia. The membrane, composed largely of amnion and disseminated masses of Wharton's jelly, was incised in an area free of intestines; the sac contained a large portion of small intestines, cecum, appendix, ascending and a part of the transverse colon; no adhesions were present except one area which evidently corresponded to the attachment of the vitello-intestinal duct; after division of this adhesion between small intestines and the sac, reduction of the contents was accomplished without difficulty. The peritoneum was closed with few interrupted catgut stitches, a purse string stitch offering technical difficulties. The cord, including the sac, was severed transversely leaving a skin covered stump ½ cm. high. A simple closure of the abdominal wall would leave a disfiguring scar; therefore an attempt was made to reconstruct a normal umbilicus by placing silk sutures through the skin in such a manner that they would invert the skin edges (Fig. 1). As such inversion of the skin could produce a *locus minoris resistentiae*, favoring development of an umbilical hernia if the edges should separate, superficial scarification of the cutis forming the cuff was employed to produce firm adherences. After four such inverting sutures had been placed through the skin around the opening in a circular manner, they were tied after preliminary approximation of the muscles and fascia with interrupted stitches of chromic catgut. The skin sutures were removed eight days after the operation, leaving an umbilicus of normal appearance.

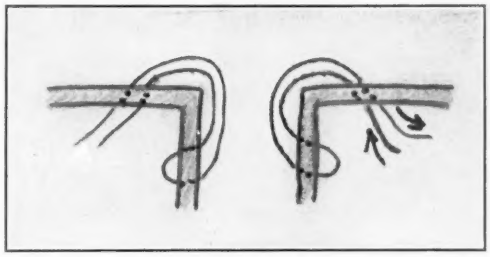

FIG. 1.—Showing method of introducing sutures to effect reconstruction of umbilical dimple.

A check-up six months and one year after the operation showed a normal appearance of the umbilical dimple and absence of bulging during crying or coughing spells. In other words, a good anatomic and cosmetic result was obtained.

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July, 1935

DIFFUSE LIPOMA OF THE RIGHT UPPER EXTREMITY

PROLAN A AND B YIELDED BY BIO-ASSAY OF FAT

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FROM THE LABORATORY OF SURGICAL PATHOLOGY OF THE JOHNS HOPKINS HOSPITAL

APPROXIMATELY 500 fatty tumors have been studied in the Laboratory of Surgical Pathology of the Johns Hopkins Hospital. Table I indicates the character and distribution of these growths. Seven of these growths have presented malignant characteristics, shown histologically by definite proliferative changes, the fat being combined with xanthomatous or myxomatous tissue, and clinically by recurrences or metastases. In 22 cases the

TABLE I

Distribution of 390 Cases of Subcutaneous Lipomas

Shoulder	60	Groin	10
Back	59	Perineum	7
Neck	54	Hand	6
Thigh	53	Forearm	2
Axilla	33	Knee	2
Buttocks	31	Foot	1
Arm	23	Scalp	1
Leg	21	Forehead	1
Chest	13	Chin	1
Abdominal wall	12		

Distribution of 70 Cases of Lipoma of the Breast and Viscera

Breast	36	Oral cavity	3
Small and large intestine	13	Bone	2
Joints	7	Kidney	1
Mesentery and retroperitoneal	7	Pleura and mediastinum	1

tumors were either multiple or diffuse. In three of the preceding group a definite familial or hereditary tendency could be determined. The following case is reported because of the unusual character of the growth.

CASE REPORT

The patient is a colored girl aged eleven years. The lesion was noted in her right hand during infancy. The attention of the parents was attracted when the child was two years of age. The right hand became puffy. This was supposed to have been caused by a mosquito bite, but it continued to increase. During the next two years the forearm and arm became affected and the swelling extended to the shoulder. When the child was four years old the arm was irradiated. When she was seven a biopsy was made, and irradiation again attempted.

The child entered the Surgical Clinic of the Johns Hopkins Hospital because of the disability caused by the weight of the upper extremity. Examination of the child revealed a well-developed colored girl of eleven years with an enormous upper extremity.

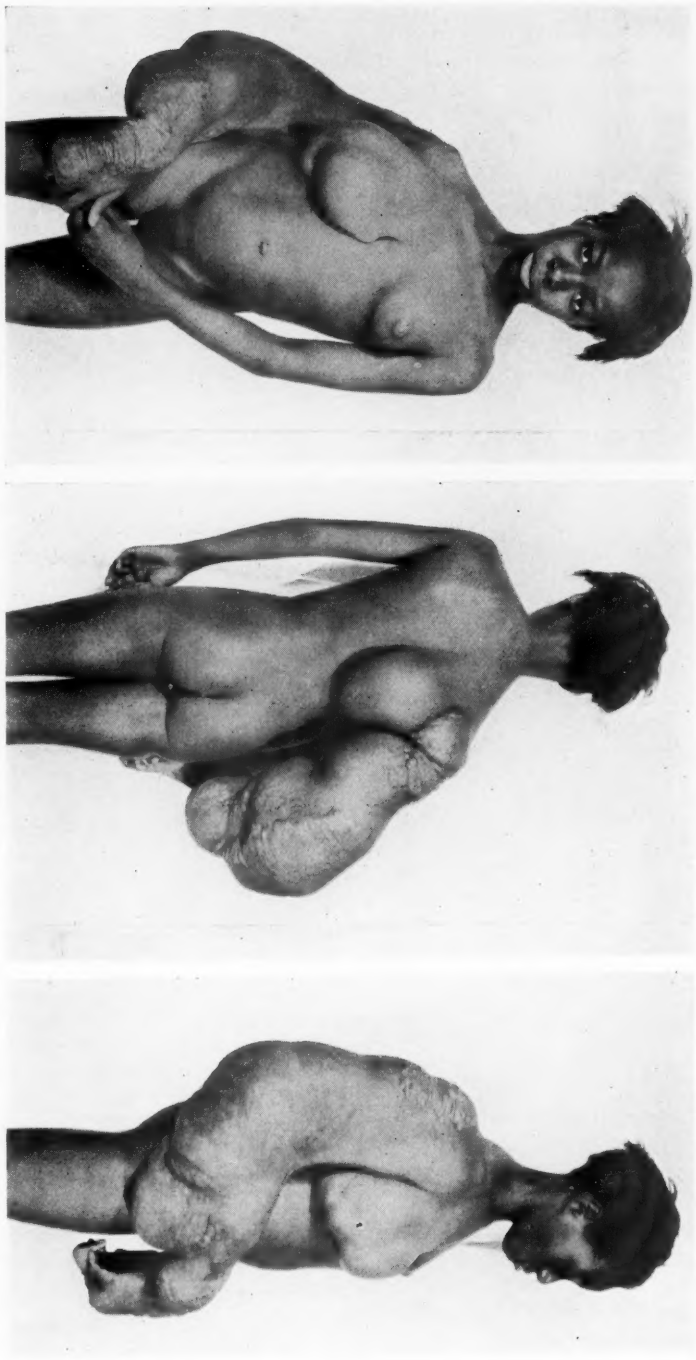

FIG. 1A-B-C (Path. No. 58529).—Photographs of the patient before operation. The fatty masses are distributed diffusely over the upper extremity and the region of the right breast and scapula. (A) shows the state of development of the external sexual organs. The breast and sex development is probably not precocious for eleven years in this race.

Subcutaneous masses, more or less elastic on palpation, could be felt at the wrist, and these extended above to the trunk, where they became continuous with a large, lobulated mass in front, which occupied the site of the breast, and another large, lobulated mass situated on the posterior surface of the thorax. The right wrist measured 24 cm. in circumference; the midforearm 47 cm. and the midarm 42 cm. The right hand, with the exception of the middle finger, appeared normal. A keloid resulting from a previous operation was found in the deltoid region on the right side. The function of the arm is surprisingly good, when its size is considered. The skin in certain areas seemed corrugated and warty, a change not infrequently associated with lymphedema. The amount of deformity causing a definite scoliosis is best indicated by the accompanying photographs. Definite bony outgrowths could be palpated on the middle finger, on the ulna and humerus.

FIG. 2 (Path. No. 58529).—Roentgenogram of the affected arm showing the irregular widening and exostoses on the ulna. The bone is overlapped by large tissue shadows.

A roentgen ray examination revealed beneath the shadows caused by the soft parts a widened shaft of the ulna, from which projected several exostoses. These outgrowths were of the rounded osteoma type, and were located at the points of the insertion of tendons (Fig .2). They apparently developed in response to pressure exerted upon the periosteal muscular attachments by the increasing weight of the tumor. The humerus was similarly affected in the lower third, and here the subperiosteal bone formation can be noted. There are no exostoses in this part of the bone.

September 10, 1934, the right arm was disarticulated at the shoulder joint. The incision in disarticulating at the shoulder joint was carried through part of the tumor which connected the masses on the anterior and posterior surfaces of the thorax. The upper extremity was then sectioned longitudinally. Large, diffuse, subcutaneous collections of fat were found, which in many places extended up to the epidermis. Several large, discrete, fatty tumor masses, some measuring 10 cm. in diameter, were found in the upper forearm and the lower part of the arm. Several intermuscular lipomas were in the forearm (Fig. 3 A-B). The fat had a peculiar milky appearance. No lymphatic cysts were found, with the exception of some small, dilated, lymphatic spaces, not true cysts, in the upper arm.

The histologic studies revealed fat cells of the adult type. An increase of the fibrous reticulum was found at the margins of the tumor. No xanthomatous or myxomatous areas are found in the fat, or any changes which might suggest that malignant changes were occurring. Dissection of the nerves revealed no sheath tumors. The nerve trunks were broadened and flattened by compression of the fat masses. Dense, osseous material projected at certain points from the shafts of the ulna and humerus. Microscopic study of these bony protuberances revealed trabeculae, such as is seen in normal adult bone.

Approximately 100 grams of fat were removed from the tumor in the fresh state. This tissue was placed in 95 per cent alcohol and forwarded to Dr. J. A. Morrell, of

FIG. 3A-B (Path. No. 58529).—(A) Specimen from forearm showing two large fatty masses in the subcutaneous region and a lobulated intermuscular lipoma. (B) Diffuse fatty deposits in the subcutaneous tissues of the arm.

FIG. 4 (Path. No. 58529).—Photomicrograph showing the adult character of the fatty substance in the tumor and the increase of the stroma. This tissue on bio-assay yielded 10 rat units of Prolan (A and B) per gram.

E. R. Squibb and Sons, through whose kindness a bio-assay of the material was made. This revealed 10 rat units of pituitary or anterior pituitary-like hormone (Prolan A and B) per gram of desiccated tissue—approximately 5,000 rat units per pound. This is approximately equivalent to 110,000 mouse units per kilo. The blood is positive for prolan during pregnancy in the mare, cow and human beings. The maximum mouse units per liter of blood in pregnancy are given as 10,000. Zondek[1] considers 50,000 mouse units per liter of urine in pregnancy as abnormally high. The following table indicates the number of units of oestrin and Prolan A and B found in the blood and urine during pregnancy in woman and the mare (Table II):

TABLE II

Hormone Content per Liter of Blood and Urine in Pregnancy in Human and Mare

	BLOOD			URINE		
	Oestrin Mouse Units	Prolan A Rat Units	Prolan B Mouse Units	Oestrin Mouse Units	Prolan A Rat Units	Prolan B Mouse Units
Woman.....	600	15,000	10,000	12,000	20,000	10,000
Mare.....	800	2,000	1,000	100,000	800	....

REFERENCE

[1] Zondek, B.: Die Hormone des Ovariums und des Hypophysenvonderlappens, p. 205. Berlin. Verlag. von Julius Springer, 1931.

FRACTURE OF THE STERNUM

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FRACTURE of the sternum is an exceedingly rare condition, and frequently complicated by fractures of the ribs or spine. Holderman[4] found 62 cases in the course of 46,237 fractures of all types, an incidence of .075 per cent. He reported three cases of his own, all occurring in miners who had suffered crushing injuries. Brown's[2] case was jack-knifed under an automobile. Giorgacopulo[3] reported a case who received a direct blow on the sternum in a fall. Stuck[8] has reviewed the anatomy and the mechanism of the fracture, as well as the diagnosis and treatment. He reports eight cases seen at the Mayo Clinic, the result of direct blows or crushing injuries.

Rothbart[6] reports a fracture of the manubrium in a woman who fell from the second story on her head, suffering a contusion in the occipital region. Pazzi[5] reports a similar instance. His patient was thrown from an automobile, striking his head in the occipital region. Neither of these cases suffered any direct injury at the site of fracture. Each of the above 15 cases were treated without surgical intervention.

Alexander's[1] two cases, on the other hand, were both old fractures with deformity. Both suffered pain and dyspnea. One in addition suffered cardiac embarrassment. Open reduction was resorted to in both. Graham reports

Stahl's[7] case, where the gladiolus was dislocated behind the manubrium. It was necessary to insert a corkscrew into the gladiolus in order to elevate into line.

CASE REPORT.—A man, 32 years old, was thrown through the top of an automobile. His chief complaint was pain in the chest. The chest was strapped and he was then brought two hundred miles to the hospital the following day. When admitted 40 hours after the accident, he was in an exhausted state, cyanotic, dyspneic, nauseated and expectorating copious amounts of bloody sputum. His temperature was 101°, pulse 120. Examination revealed a contusion of the occipital region. There was present a painful swelling over the center of the sternum, but no ecchymosis or abrasion about this, or any

FIG. 1.—The sternum with the manubrium displaced posteriorly and overriding the upper border of the gladiolus.

FIG. 2.—The sternum after the manubrium had been elevated into alignment with the gladiolus.

sign of direct injury. The heart borders were 12 cm. to the left and four cm. to the right. There was a loud presystolic murmur at the apex and in the second left interspace. There was impaired resonance at the bases of both lungs, with moist râles. He was given morphine and digitalized. His general condition precluded any further examination or manipulation of the sternum. He was radiographed two days later. These revealed a luxation of the manubrium of the sternum on the gladiolus. The manubrium was displaced posteriorly a distance of its entire thickness and was overriding about one-half inch. There was fragmentation of the manubrium and the gladiolus at the site of their approximation (Fig. 1).

Attempts to reduce this by manipulation and hyperextension and strapping were unsuccessful. They also had such an unfavorable effect upon the patient's cardiac condition that we were forced to discontinue any such attempts.

As the patient improved he continued to suffer pain in and about the sternum which was aggravated by coughing and bending his head forward. Several other unsuccessful efforts were made at reduction. On the tenth day the patient's general condition had improved sufficiently to permit an anesthetic. Under ethylene and gas, an incision was made about three inches in length over the center of the sternum. A corkscrew was inserted into the manubrium and upper and anterior traction was made. A periostal elevator was slipped between the two bones and used as a pry The manubrium was lifted up into place (Fig. 2) and the periosteum and fascia sutured snugly so as to hold it from slipping back. The skin was closed with interrupted dermal sutures. A pressure pad was applied to the gladiolus, and the shoulders were strapped with a figure of eight bandage.

The patient had a stormy convalescence, but was able to leave the hospital at the end of the third week. Subsequent radiograms revealed dense callus formation at the site of fracture. Some three months later an area of necrosis appeared at the junction of the manubrium and the gladiolus. This was thought to be a small abscess containing a sequestrum. It was opened into and the cavity curetted and allowed to granulate. He has had no further trouble.

REFERENCES

[1] Alexander, J.: Traumatic Pectus Excavatum. ANNALS OF SURGERY, vol. 93, pp. 489–500, 1931.

[2] Brown, R.: Dislocation of the Manubrium of the Sternum. Surg. Clin. N. Amer., vol. 2, No. 5, October, 1931.

[3] Giorgacopulo, G.: A Case of the Fracture of the Sternum. Arch. ital. de chir., vol. 32, p. 181, August, 1932.

[4] Holderman, H. H.: Fracture and Dislocation of the Sternum. ANNALS OF SURGERY, vol. 88, pp. 252–259, August 28, 1928.

[5] Pazzi, E.: Anterior Luxation of the Body of the Sternum on the Manubrium Shown by Roentgen Examination. Arch. di. radiol., vol. 2, pp. 569–576, July–August, 1926.

[6] Rothbart, L.: Fracture of the Manubrium of the Sternum. Fortschritte auf dem Gebiete der Roentgenstrahlen, vol. 40, p. 89, 1929.

[7] Stahl, E. T.: Quoted by Graham, E. A.: The Year Book of General Surgery, p. 265.

[8] Stuck, W. G.: Fractures of the Sternum. Am. Jour. Surg., New Ser., vol. 22, pp. 266–270, 1933.

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